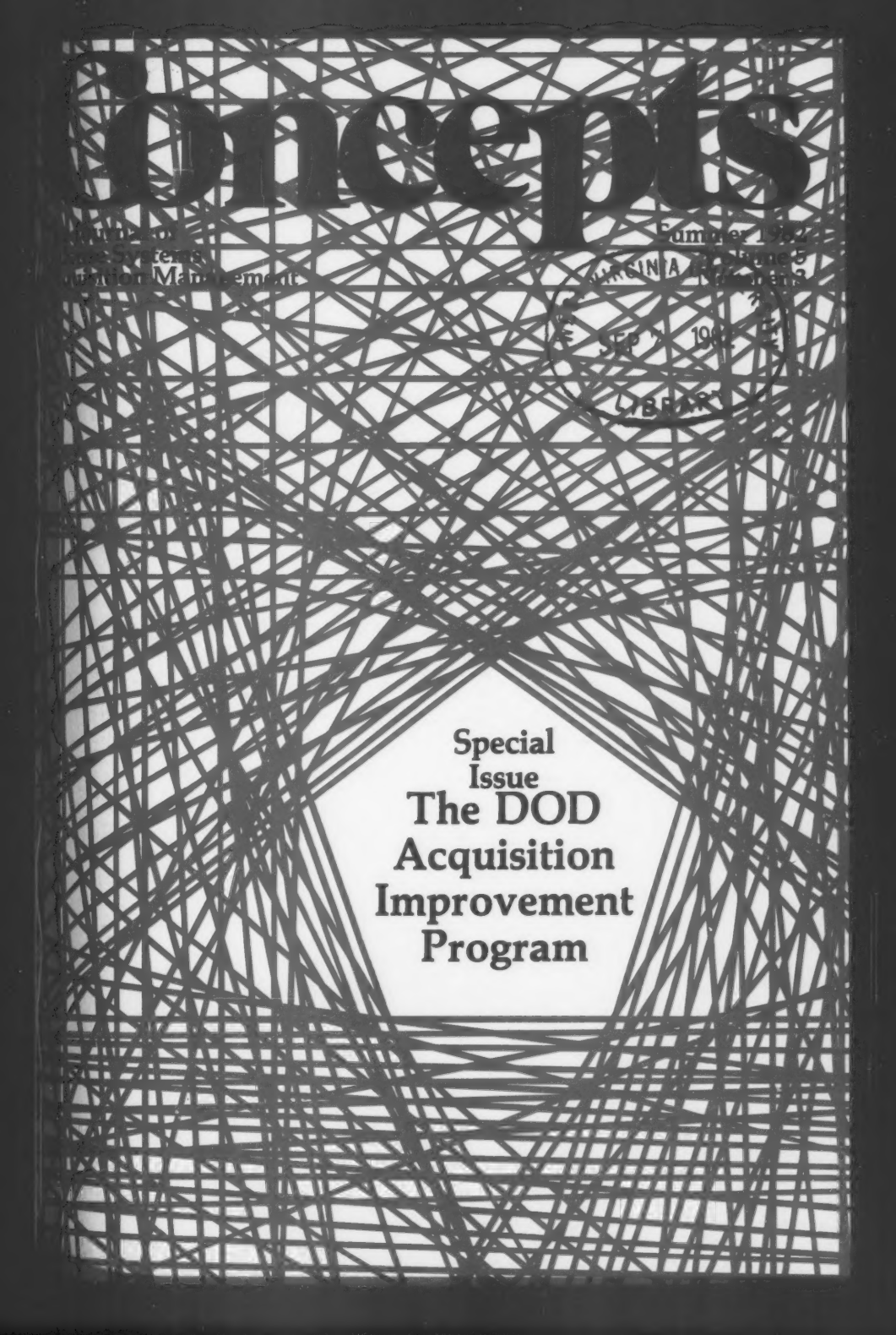
Concepts
Special
Issue
The DOD
Acquisition
Improvement
Program

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Concepts

The Journal of
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9 **The New Acquisition Environment: Challenge and Opportunity**
Lieutenant Colonel John D. Edgar, USAF

This first article sets the stage for the other articles in the special issue by reviewing the successes of the DOD Acquisition Improvement Program over the past year and challenges the reader to take the initiative in implementing selected actions in his own program.

16 **A Cultural Change: Pre-Planned Product Improvement**
Lieutenant Colonel Garcia E. Morrow, USA
Dr. Jules J. Bellaschi

Action 2 of the Acquisition Improvement Program directs that greater emphasis be placed on pre-planned product improvement (P^3I) during system development. The authors discuss the P^3I concept, the status of the DOD plan for implementing it, the criteria for application, and considerations for the PM.

26 **Increasing Competition in the Acquisition Process** *John C. McKeown*

Current activity within the Acquisition Improvement Program is designed to rekindle interest in competition. This paper discusses the benefits of competition that go beyond cost, to include stimulation of innovation in manufacturing as well as technology and design and a strengthened industrial base.

34 **Improving the Source Selection Process** *Manfred J. Reinhard*

The author discusses the problems with the source selection process identified by the working group chartered by Deputy Secretary Carlucci. This paper describes the problems and the actions taken to correct them, and also addresses the changes that are expected to be incorporated in the revised DOD directive covering source selection.

44 **Determining the Appropriate Contract Type**
Commander Frank T. Meneely, USN

In any acquisition program, much depends on the selection of the appropriate contract type. Unfortunately, this is not always an easy choice to make. In this paper the author discusses the selection of contract type in major systems acquisition, including: guidelines provided to the contracting officer, the concerns of industry, and the actions taken by the DOD Acquisition Improvement Task Force that influence the selection of contract type.

50 **Action 21: Standard Operation and Support Systems**
Colonel Walker A. Larimer, USAF

The author discusses the potential of Action 21 to save money, enhance support, and increase force readiness. He describes the three-phase Action Plan developed to improve standardization, and assesses progress to date in meeting standardization objectives.

60 **Controlling Murphy: How to Budget for Program Risk**
Lieutenant Colonel John D. Edgar, USAF

Providing for risk in an acquisition program is one of the more difficult challenges facing the program manager. The author discusses DOD Acquisition Improvement Program Action 11, covering the reasons programs involve risk, the need to budget funds to deal with those risks, and the general techniques available to estimate the amount of funds required.

74 **The Acquisition Process: A Brief Historical Perspective**
David D. Acker

At the close of the 1960s, the Laird/Packard team initiated a number of actions aimed at improving the management of the defense systems acquisition process and gaining control of costs. This paper reviews in some detail the actions taken by this team, and the refinements to the process and its management during the decade of the '70s.

83 **The Acquisition Process: New Opportunities for Innovative Management**
David D. Acker
George R. McAleer, Jr.

This paper describes the changes made to the Defense Resources Board, the Defense Systems Acquisition Review Council, and the basic acquisition process in support of the DOD Acquisition Improvement Program. Several challenges still facing the acquisition management community are placed in focus.

96 **Design-to-Cost and the Acquisition Improvement Program**
Major Raymond H. Barley, USAFR

The design-to-cost concept has been in use for a number of years, but its use could be expanded. The author discusses the use of incentives to make design-to-cost a more viable management tool and provides real-world examples of the use of the concept in active programs.

112 **Enhanced MYP for Improving Weapon Systems Acquisition**
Dr. Abraham Singer
Colonel G. Dana Brabson, USAF

Much of the activity in the Acquisition Improvement Program has revolved around multiyear procurement (MYP). The authors review the latest progress in MYP and discuss the remaining issues that still need to be resolved in order to establish a framework that would permit widespread use of MYP, particularly on major systems.

130 **Contractor Incentives to Improve Reliability and Support**
Dr. John P. Solomond

This paper (1) identifies the shortfall in support and readiness, and shows how the Acquisition Improvement Program addresses the readiness problem; (2) examines the use of incentives to motivate contractor performance in reliability and support; and (3) contains a discussion of five weapon system programs that have used warranties or incentive contracting techniques.

148 **Program Stability: An Essential Element in Improved Acquisition**
Harold J. Schutt
David D. Acker

The authors argue that one approach to achieving program stability is to designate a few programs within each service for stabilization, and to achieve that stability by forcing cost flexibility on the remaining programs. To maintain stability, all levels—program management, the services, OSD, and the Congress—must honor this approach and not cause perturbations in the programs designated as stable.

161 **Readiness: Coequal** *Colonel G. Dana Brabson, USAF*

For quite some time it has been recognized that readiness has not been given the same emphasis in system development programs as such other parameters as cost, performance, and schedule. This paper is intended to focus the reader's attention on the key elements of a strategy developed jointly by OSD and the services to significantly enhance the readiness of U.S. forces by bringing the consideration of readiness more into line with that given to other major program objectives.

190 **Enhancing Productivity Through Increased Capital Investment**
Dr. Andrew P. Mosier

The author describes actions in an integrated program to encourage productivity-enhancing investments by contractors to significantly improve their productivity on an acquisition program, and in the aggregate, improve the productivity and responsiveness of the U.S. defense industrial base for peacetime, surge, and mobilization production. The program makes industrial preparedness an integral part of acquisition by integrating the eight actions directed by Acquisition Improvement Program Action 5 (entitled "Encourage Capital Investment to Enhance Productivity") and the acquisition process actions recommended in March 1982 by the DOD Task Force to Improve Industrial Responsiveness.

215 **Appendix—DODD 5000.1**

from the editor . . .

Although few of you were aware that we were even planning an issue of *Concepts* devoted to the DOD Acquisition Improvement Program, those of us here at the College, and a few elsewhere, have been immersed for months in the project. The first impetus came last October when Colonel G. Dana Brabson, USAF, Dean of the Department of Research and Information here (and author or co-author of several articles and briefings having to do with the improvement program), suggested we publish a special issue of *Concepts* to let acquisition managers know where we stand with many of the improvement actions today—a little more than a year after they were developed. Lieutenant Colonel John D. Edgar, USAF, Director of DSMC's Research Directorate, then assumed control of the project. Lieutenant Colonel Edgar determined who the authors should be, "commissioned" the papers to be written, and made the final decisions regarding the appropriateness of the finished products. In effect, Lieutenant Colonel Edgar served as the "editor" for this issue, at least in terms of general guidance and content control. We of the publications staff came into the picture late, after the more difficult work had been done. So, for the usefulness of this special issue of *Concepts* you can thank Colonel Brabson and Lieutenant Colonel Edgar and everyone else who contributed along the way, including the authors and the many reviewers of each paper.

Our next issue will be devoted to software acquisition and the challenges and opportunities associated with it. With a great deal of invaluable assistance from the Electronic Industries Association, we have assembled some significant papers on this topic. Those of you involved in any way with the development and acquisition of software for military applications should make it a point to see our autumn issue.

Foreword to Special Edition

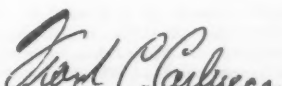
A year ago, when I addressed the opening convocation of Program Management Course 81-2, I noted that there was a national consensus to rebuild our defense. That consensus still exists. Today, perhaps as never before, it is vitally important for us to sustain that consensus by demonstrating that we are capable managers of the resources entrusted to us.

As I reflect over the past year, I am pleased to report significant progress toward our objective of improving the acquisition process. We *have* decreased the number of programs over which the Secretary of Defense retains decision-making authority; the principle of controlled decentralization is being embraced by the services. We *have* achieved economies in the acquisition process; major multiyear procurements are in place, and selected programs have been restored to economic production rates. We *have* begun to make the defense marketplace more attractive to industry; flexible progress payments are easing cash-flow problems, and increased investments in manufacturing technology are accelerating the pace of modernization. We *have* increased the readiness of our systems in the field; supportability and maintainability are being accorded the same emphasis as cost, schedule, and performance, and recent budget decisions provided additional resources to support the readiness of key systems.

Important as these achievements are, much of the challenge still lies before us. There are no magical solutions; the problems are far too complex and result from factors over which we have limited control, and the progress we have made to date can be easily lost. For this reason, it is important for each of us to carry the fight forward. Progress will depend on innovation and, above all, on initiative. We need your ingenuity; we need your ideas as to how to apply the acquisition improvement actions we have set in motion; we need your work in the trenches to bring proposals forward; and we need your persistence in the face of odds that sometimes seem insurmountable.

The objective of this issue of *Concepts* is to assist you as you accept this challenge. The articles focus on the actions that program managers and the people in the program management office can take to improve the acquisition process for their own systems. Taken collectively, the initiatives of all the program management offices *will* enable us to sustain the consensus to rebuild our defense.

We have a paramount public trust—the security of this nation. Providing a defense second to none is essential to this trust. I am convinced that we can do it. We must not be sidetracked.



FRANK C. CARLUCCI
Deputy Secretary of Defense

9 The New Acquisition Environment: Challenge and Opportunity

Lieutenant Colonel John D. Edgar, USAF

A year has passed since Deputy Secretary of Defense Frank C. Carlucci issued his April 30, 1981, memorandum on "Improving the Acquisition Process." In that time, significant changes have been made in the planning, programming, and budgeting system (PPBS) and the acquisition process. However, much remains to be done to fulfill Secretary of Defense Caspar W. Weinberger's promise "to demonstrate to the American taxpayer that we can and will manage our large, complex, and critically needed defense establishment in a prudent and businesslike manner."[1] That is the challenge and the opportunity for the program managers and their staffs, because much of the responsibility for fulfilling this promise rests with them.

By now most of the acquisition community has been exposed to the 32 actions that make up the Department of Defense (DOD) Acquisition Improvement Program. The Defense Systems Management College (DSMC) has taken an active role in getting the word out. All the courses at DSMC include presentations on the Acquisition Improvement Program. Similar presentations by DSMC have been given at the field activities of the services' acquisition commands, as well as at meetings of professional societies. Articles on the Acquisition Improvement Program have appeared in DSMC's two publications, *Program Manager* and *Concepts*, which are widely distributed to people working in the systems acquisition business.

The purpose of this special issue of *Concepts* is to carry that education process one step further. We have brought together current information on a selected group of the actions that program managers can incorporate into their programs. Each of these actions is covered in a separate article. The articles emphasize the practical factors a program manager should consider in deciding if the action can benefit his program, including descriptions of how the actions have been used in other programs. The articles also identify policy documents, procedural directives, and other information sources that a program manager can use in implementing the actions.

The purpose of this article is to provide a status report that outlines, in general terms, what has happened during the past year. The major successes that will be touched on are summarized in Figure 1.

1. Caspar W. Weinberger, "Where We Must Build—And Where We Must Cut," *Defense/81* December 1981, p. 10.

Lieutenant Colonel John D. Edgar, USAF, is Director of the Research Directorate in DSMC's Department of Research and Information. From 1976 to 1980 he was assigned to Headquarters Air Force, Deputy Chief of Staff/Research, Development, and Acquisition, where he was responsible for congressional liaison activities in support of the Air Force R&D and procurement budgets. Lieutenant Colonel Edgar holds B.S. and M.S. degrees in aeronautics and astronautics and an E.A.A. degree from M.I.T., and an M.B.A. degree from Auburn University. He is also a graduate of DSMC's Program Management course.

FIGURE 1

Progress Summary

- ☑ MULTIYEAR PROCUREMENTS APPROVED IN FY 82
- ☑ ADMINISTRATIVE THRESHOLDS RAISED
- ☑ VINSON-TRAMMELL PROFIT LIMITATIONS REPEALED
- ☑ REPROGRAMMING THRESHOLDS RAISED
- ☑ ACCELERATED COST RECOVERY AUTHORIZED (BUT CAS 409 NOT YET REVISED)
- ☑ DSARC THRESHOLDS RAISED
- ☑ FLEXIBLE DSARC MILESTONES IMPLEMENTED
- ☑ FLEXIBLE PROGRESS PAYMENTS AUTHORIZED
- ☑ FUNDS ADDED TO FY 83 BUDGET REQUEST FOR
  - MORE REALISTIC INFLATION RATES
  - BUDGETING TO MOST LIKELY COSTS
  - BUDGETING FOR TECHNICAL RISK
  - MORE ECONOMICAL PRODUCTION RATES
  - MULTIYEAR PROCUREMENTS
  - PRODUCTIVITY INVESTMENTS

☑ SIGNIFICANT PROGRESS MADE

☑ SUSTAINED INTEREST AND CONTINUED WORK REQUIRED FOR COMPLETE SUCCESS

To begin with, the fiscal year (FY) 1982 defense budget was passed by Congress in December of last year. The budget, originally prepared by the Carter administration and later revised by the incoming Reagan administration, achieved mixed results.

Multiyear Procurement

On the positive side of the ledger, multiyear procurements were approved for the Navy's C-2A carrier onboard delivery (COD) aircraft and the Air Force's F-16 aircraft and AN/TRC-170 radio. It has been estimated that these three pro-

curements will save the taxpayers about $325 million. The use of multiyear procurement (MYP) on these programs was encouraged by passage of section 909 of *Public Law 97-86* which raised the cancellation ceiling on MYP. The Congressional Appropriations Committee, OMB, and the Secretary of Defense desire to avoid unfunded MYP cancellation costs. Therefore, the Secretary requires the services to fund advance procurement for MYP on a termination liability basis, which requires considerable front-end funding. The article by Dr. Abraham Singer, which appears later in this volume, provides a more complete story on the advantages and problems of multiyear procurement.

Administrative Thresholds

Also on the positive side, the authorization act, Public Law 97-86, raised a number of administrative thresholds. Over the years, through the effects of inflation, more and more procurement actions were exceeding the thresholds and being subjected to increased administrative burdens. To reverse this trend, simplified small-purchase procedures are now authorized on contracts up to $25,000 (10 U.S.C. 2304); the old limit was $10,000. The level at which contractors must submit certified cost or pricing data prior to the award of negotiated contracts has been raised to $500,000 from $100,000 (10 U.S.C. 2306). The threshold for secretarial determination and findings (D&F) on negotiated research and development contracts is now $5 million, up from $100,000 (10 U.S.C. 2311). The authorization act also repealed the provisions of the 1934 Vinson-Trammell Act which limited profits on aircraft procurement contracts to 12 percent (10 U.S.C. 2382) and on ship construction contracts to 10 percent (10 U.S.C. 7300). In its place, the President has been given authority to control excessive profits on defense contracts during periods of national emergency. This action, along with the capital investment incentives described in the article by Dr. Andrew P. Mosier, is intended to make defense work more attractive to contractors.

Positive changes also occurred as a result of the congressional deliberations on the FY 1982 appropriations bill. The DOD asked the four congressional authorization and appropriations committees to raise the reprogramming thresholds from $2 to $10 million for research, development, test and evaluation (RDT&E), and from $5 to $25 million for procurement—a fivefold increase. The two authorization committees agreed to the increase; however, as a result of a compromise reached in the House-Senate conference on the appropriations bill, the reprogramming thresholds have been doubled to $4 million and $10 million for RDT&E and procurement, respectively.

Program Turbulence

On the other hand, continued program turbulence resulted from the lack of a clear definition of long-range defense policy, strategy, and resources. That, in turn, prevented the services from establishing mission priorities. Without those

priorities, marginal or low-priority programs could not be identified and then terminated to allow full funding of higher priority programs. A discussion of the actions under way to achieve greater program stability in the future appears in the article by Messrs. Harold J. Schutt and David D. Acker.

Capital Investment in Defense Industry

Another major change introduced by the Reagan administration and passed by Congress was the Economic Recovery Tax Act (ERTA) of 1981. Several provisions of this act are designed to encourage more capital investment by industry with the objective of increasing productivity. The provisions dealing with the depreciation, or cost recovery, of capital assets are particularly important for defense industries. In essence, the accelerated cost recovery system (ACRS) contained in the ERTA defines four categories of capital assets with cost recovery allowed over periods of 3, 5, 10, and 15 years—much shorter times than previously allowed.

Contractors doing business with DOD are also bound by Cost Accounting Standard (CAS) 409, "Depreciation of Tangible Capital Assets." CAS 409 requires that depreciation, for defense contract cost recovery purposes, be based on the historical or economical useful life of capital assets—a much longer period than now allowed under the ACRS. It will be some time before CAS 409 can be revised to allow defense contractors to use accelerated cost recovery. The reason is that the Cost Accounting Standards Board, an agent of Congress, has gone out of existence. Legislation is being prepared to transfer its functions to OMB. The DOD is supporting this transfer and the subsequent amendment or repeal of CAS 409.

The (S)SARC/DSARC Process

Within the DOD itself, the results achieved in calendar year 1981 were also mixed. Positive action was taken to increase the dollar thresholds at which programs are subject to review by the Defense Systems Acquisition Review Council (DSARC). As a result of doubling the dollar thresholds and indexing them for inflation, 10 programs were delegated back to the services—a 20 percent reduction in the number of DSARC-level programs. The Army and Navy have followed DOD's lead and increased the thresholds for their service SARCs.

Similarly, the new, more flexible DSARC milestones have also been implemented. The production decisions (old Milestone III) have been given back to the services on the Tomahawk cruise missile, the Hellfire missile, and the KC-135 re-engining program. Both the Milestone II and III decisions for the Over-the-Horizon Backscatter (OTH-B) radar system have been delegated back to the Air Force. Less formal program reviews, in lieu of DSARC Milestone III, have been held for the F/A-18 aircraft, the Imaging Infrared Maverick missile, and the LAMPS helicopter. Using the more flexible guidelines, delayed Milestone II deci-

sions have been scheduled for the Seek Talk program, the Advanced Medium Range Air-to-Air Missile (AMRAAM), and the Near-Term Scout Helicopter. The program go-ahead decisions for the AMRAAM and the Near-Term Scout Helicopter have been scheduled to coincide with their preliminary design reviews (PDR). The decision on the Seek Talk communications program has been delayed until the critical design review (CDR). Finally, the requirement validation decisions (Milestone I) for Near-Term Scout Helicopter and the DDGX multimission destroyer have been delegated back to the services. These and other changes in the DSARC process are covered in greater depth in the article by Messrs. David D. Acker and George R. McAleer, Jr.

Progress Payments

Another positive action taken by DOD was to increase progress payment rates and establish a flexible progress payment procedure.[2] This action was designed to decrease the contractor's level of investment in work in progress. As interest rates rose dramatically in recent years, the contractor's financing costs for this investment increased and, not being allowable contract costs, reduced his profit rate. This made defense work much less attractive to many firms, particularly small businesses and subcontractors.

Under the new policy, a contractor can now request uniform, standard progress payments of 90 percent, up from 80 percent (DAR 7-104.35a). For small businesses, the new rate is 95 percent, up from 85 percent (DAR 7-104.35b). In the process, the frequency of payments was changed from biweekly to monthly.

For negotiated fixed-price contracts in excess of $1 million, the contractor may request flexible progress payments (DAR Appendix E-530). The contractor supplies cash-flow data to be used in the DOD cash-flow computer model, which computes the flexible progress payments. The government will make progress payments at a rate that yields a contractor investment in work in progress of at least 5 percent. However, in no event will the rate be greater than 100 percent, or less than the appropriate uniform, standard rate.

Implementing the Acquisition Improvement Actions

From the beginning, Deputy Secretary Carlucci recognized that making decisions in government is only half the task; making sure the decisions are carried out is equally important. Constant pressure must be exerted to overcome bureaucratic inertia. For that reason, Mr. Carlucci gave Dr. Richard D. DeLauer, the Under Secretary of Defense for Research and Engineering (USDRE), overall responsiblility for monitoring implementation of the 32 actions. Monthly progress reports were prepared and sent to Deputy Secretary Carlucci.

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2. Robert F. Trimble, memorandum for the Assistant Secretaries of the Military Departments, and others, subject: "Flexible Progress Payments," 28 August 1981.

After 6 months, it became apparent that implementation was not as rapid or forceful as expected. Therefore, on November 17, 1981, Mr. Carlucci chartered a Task Force on Acquisition Improvement to evaluate the progress on each action, to identify any barriers to implementation, and to provide a plan for overcoming those barriers. The Task Force, led by Mr. William A. Long, Deputy Under Secretary of Defense (Acquisition Management), reported its findings to the Deputy Secretary on December 23, 1981. The Task Force concluded that, "The magnitude of our current affordability and prioritization problems constitutes an underlying barrier" and that complete implementation will require "extraordinary management action on a systemic, or systems, approach."[3]

Following submission of the Task Force report, the FY 1983 budget request was sent to Congress. The request for $258 billion in total obligation authority provides an increase of $43.7 billion over FY 1982. Two-thirds of that increase is in the RDT&E and procurement accounts. Much of the added money will be used to implement various acquisition improvement actions. The budget actions proposed are summarized below with further details provided in other articles in this issue.

Budgeting for Inflation and Risk

In FY 1983, more realistic inflation rates have been used in nine of the major commodity procurement appropriations.[4] Historically, inflation rates experienced in these appropriations have been higher than those in the general economy. This resulted in $2.2 billion being added in FY 1983 alone. Likewise, money was added to allow program managers to budget to most-likely costs (Action 6) and to budget for technological uncertainty (Action 11). Almost $2 billion was added to 22 major programs just to realistically buy the quantities of equipment planned last year. Twelve major Army programs included $87.1 million for technical risk. Another article later in this issue provides more information on the Army's total risk assessing cost estimate (TRACE), as well as the Navy and Air Force techniques for dealing with risk.

Program Stability and Productivity

Working toward increased program stability, the FY 1983 defense budget request included an additional $2.8 billion which will raise production rates on 14 selected programs to more economical levels. The new budget request also included $546 million in FY 1983 for "up front" funding of 14 major multiyear procurements. These 14 procurements will yield a net savings of $815 million over the next 5 years.

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3. U.S. Department of Defense, *Final Report of the Task Force on Acquisition Improvement*, 23 December 1981.

4. John R. Quetsch, memorandum for the Assistant Secretaries of the Military Departments, and others, subject: "Price Escalation Indices," 26 January 1982.

The budget request also contained funds to enhance productivity both at in-house production operations and contractor plants. Seventy-two in-house productivity investment projects requiring $121 million in FY 1983 are expected to yield a 5-year savings of $558 million. The FY 1983 request also included a total of $271 million for manufacturing technology (MANTECH) programs.

As I have tried to show, our progress in reforming the acquisition process has been significant; however, the key to its complete success lies in the sustained interest and continued work by decision-makers *at all levels.* That is the challenge that has been given to you. We hope that the information contained in this issue will motivate you to seize the opportunities provided by the DOD Acquisition Improvement Program so that you can meet the challenge.

A Cultural Change: Pre-Planned Product Improvement

16

Lieutenant Colonel Garcia E. Morrow, USA
Dr. Jules J. Bellaschi

Since the Korean War, the prevalent weapon system acquisition strategy of the United States has been to develop and deploy systems at the frontier of technology. This revolutionary system development strategy used high-risk technologies and frequently resulted in a lengthening of the acquisition time and an increase in weapon systems cost. The United States has concentrated on producing sophisticated weapon systems that have been reactive to changes in threat and technology. In contrast, the Soviet Union has concentrated on developing and deploying less-sophisticated, but more numerous, weapon systems.

Dr. William J. Perry, former Under Secretary of Defense for Research and Engineering, emphasized the concerns of the Department of Defense over the disparity of military weapon systems production between the United States and the Soviet Union in his testimony to the 97th Congress on the DOD FY 1982 program for research, development, and acquisition of weapon systems. Dr. Perry stated that the Soviet Union is out-investing the United States in military investment by about a 2:1 margin, and out-producing the United States in most categories of military equipment by more than a 2:1 margin. Figure 1 illustrates the ratio for production of tactical weapons between the Soviet Union and the United States during the period 1976–80.

Two important factors to note are that the Soviet systems now being deployed increasingly match the quality of U.S. deployed systems, and the Soviet Union's military research and development effort is twice as great as that of the United States.

During the past two decades, the United States has tried to offset the widening gap in military hardware with the Soviet Union by modernizing and extending the life of existing weapon systems through product improvement (PI)[1] or planned product improvement (P^2I)[2] programs. Again, these reactive programs

1. Product improvement is a configuration change to a type-classified weapon system or component requiring engineering, testing, and, usually, the procurement and installation of modification kits. *Materiel Acquisition Management Guide*, U.S. Army Materiel Development and Readiness Command, February 1980, Part III, p. 86.

2. Planned product improvement is a subset of P^3I and is the planning of improvements to existing systems, even though the architecture of the systems was not structured, nor the stepped requirements established during the Concept Exploration or Demonstration Validation phase. Hylan B. Lyon, Jr., "The Pre-Planned Product Improvement Initiative—Idealism vs. Reality," 13 August 1981.

Lieutenant Colonel Garcia E. Morrow, USA, is Special Assistant for the Contractual Program in DSMC's Department of Research and Information. Prior to this assignment he was on the Joint Strategic Target Planning Staff at Offutt Air Force Base, Neb. Lieutenant Colonel Morrow holds a B.S. degree in mathematics/physics from St. Lawrence University.

Dr. Jules J. Bellaschi is on a 1-year assignment to DSMC where he holds the Department of the Navy Chair in the Executive Institute. From 1975 to 1981 he was Deputy Director, Surface Warfare Systems Group, at the Naval Sea Systems Command. Dr. Bellaschi holds a B.S. degree in engineering from Stanford University; an M.S. degree in industrial management from M.I.T.; a Ph.D. degree in operations research, systems analysis, production, general management, and managerial economics from the American University; and an LL.B. degree from Blackstone School of Law.

FIGURE 1
Production Summary of Selected Tactical Weapons or NATO[1] and WP Countries

Weapon	1976-1980 Annual Average Ratios		1980 Ratios	
	USSR/U.S.	WP/NATO	USSR/U.S.	WP/NATO
Tanks	2.5:1	2:1	4:1	3:1
Other Armored Vehicles[2]	6:1	3:1	12:1	3:1
Artillery (Over 100 mm)	20:1	8:1	5:1	2:1
Tactical Combat Aircraft[3]	2:1	1:1	2:1	1:1
Military Helicopters	3:1	1:1	3:1	1:1
SAMs (Not Man-portable)[4]	17:1	7:1	9:1	5:1
Major Naval Surface Combatants (Over 1,000 tons)	1:1	1:2	1:1	1:2
Attack Submarines	3:1	1:1	9:1	2:1

1. Includes France.
2. Includes light tanks, infantry combat vehicles, armored personnel carriers, reconnaissance vehicles, and fire-support and air-defense vehicles.
3. Includes tactical fighter, attack reconnaissance, electronic warfare, and all combat-capable tactical training aircraft.
4. USSR and WP figures include SAMs for other countries

(Pg. 11-25, Dr. Perry's Statement to the 97th Congress, 1st Session)
20 January 1981

have proved costly and have usually resulted in increased logistical support requirements. Some examples of systems that have undergone either PI or P^2I include the B-52, Hawk, Nike Hercules, F-16, and the M60A1 tank. The Air Force has spent $4 billion for PI to the B-52 over the past 26 years. The Army, on the other hand, programmed between 400 and 800 PIs for the period 1978 to 1982 at a cost in excess of $1 billion.

Pre-Planned Product Improvement

Faced with the widening gap in military hardware between the United States and the Soviet Union and the rising cost of new military systems, the Department of Defense instituted an Acquisition Improvement Program in 1981. One of the initiatives set forth in the Deputy Secretary of Defense memorandum of April 30, 1981, to improve the acquisition process addressed an evolutionary acquisition concept called "pre-planned product improvement" (P^3I). This evolutionary approach is designed to shorten the time required to field new weapon systems by fielding systems using relatively mature technology and planning for incorporation of advanced technologies after the system is deployed. This concept will require extensive early planning, as early as the conceptual phase, with respect to technology development, design requirements for future growth of the system, manufacturing, and integrated logistic support considerations. This planning will

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also require the identification of funding requirements to support developing the technologies and system upgrades.

DOD Implementation Plan

On July 6, 1981, Deputy Secretary of Defense Frank C. Carlucci issued an implementation plan for P^{3}I. The plan defines the concept as follows: "P^{3}I is an acquisition concept which programs resources to accomplish the orderly and cost effective phased growth of a system's capability, utility, and operational readiness."

The memorandum further stated the following objectives of P^{3}I:

—Shorten the acquisition and deployment time for a new system or incremental capability;

—Reduce overall acquisition, operating, and support costs;

—Extend useful life of equipment;

—Combat military obsolescence;

—Reduce technical, cost, and schedule risk;

—Accomplish orderly growth from initial to mature system reliability; and

—Reduce logistics and support problems entailed with new material introduction.

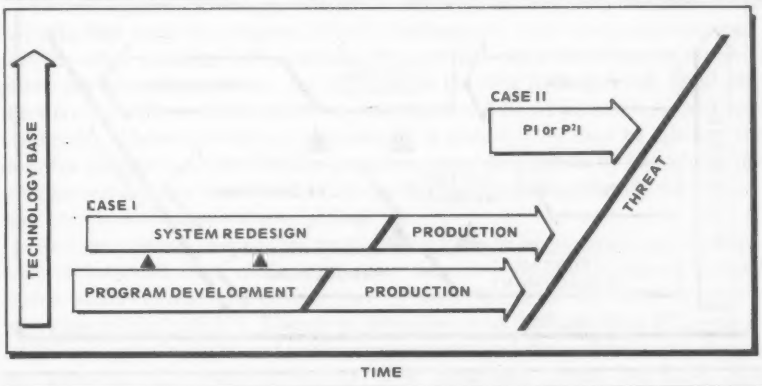
The services were directed to examine all ongoing, as well as recently fielded, major programs for potential P^{3}I applications, make candidate lists, estimate the benefits, and make programatic recommendations as part of the next system milestone decision-point briefing. The acquisition strategy for all new programs will include consideration of P^{3}I and identify funding, if appropriate, in the planning, programming, and budgeting (PPBS) cycle. In an effort to more effectively and efficiently manage P^{3}I application, the services have established focal points charged with overall P^{3}I responsibilities and chartered to review all programs for application of P^{3}I strategy and planning. The plan directed that P^{3}I be promulgated in revisions to DODD 5000.1, "Major System Acquisitions," and DODI 5000.2, "Major System Acquisition Procedures."

The P^{3}I Concept

The current DOD acquisition process is based on an understanding of the threat environment for a given mission area. Once the threat is validated, technology is developed to build a weapon system that will allow for production and deployment to meet that threat, as shown in Figure 2.

However, during system development and production, both the technology base and the threat may change. There are two approaches that have been used to cope with such changes. One has been to redesign the system during development, illustrated by Case I, to incorporate new technology that will increase the system capabilities. This approach frequently resulted in the stretching out of the programs, with a corresponding increase in system costs. The second has been to

FIGURE 2
Acquisition Concept

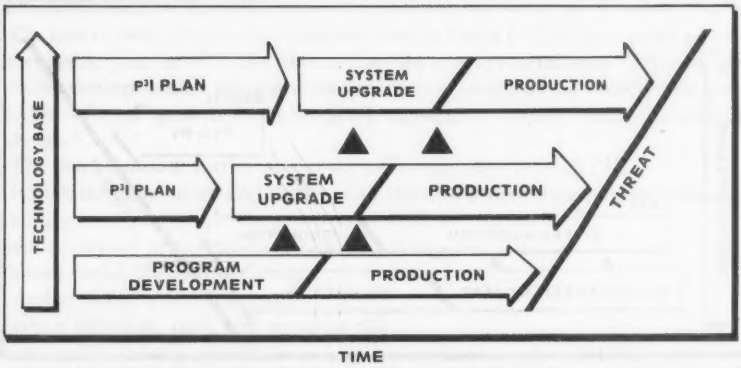


field the basic system and incorporate new technology to increase system capabilities after fielding through either product improvement (PI) or planned product improvement (P^2I) programs, as illustrated by Case II. The latter approach has resulted in systems being fielded with capabilities insufficient to meet the changing threat. Furthermore, funding for PI or P^2I programs to upgrade the systems may be delayed or totally canceled.

The concept of P^3I will allow for the evolutionary growth or upgrade of a system and be responsive to the time-sensitive changes of both technology and threat, as illustrated by Figure 3.

This approach differs from the two discussed earlier in that during the Concept Exploration phase, only relatively mature technologies will be considered in system design. However, the program manager (PM) will consider stepped enhancements, or upgrades to the system at specifically defined points in time based on a postulated change in threat or change in the technology base. When this concept is considered appropriate, the PM will include it in his acquisition strategy and reflect it in the detailed system program management document schedules and resource computations. Resources to accomplish P^3I will be made visible during the PPBS cycle and will be identified in the five-year defense program (FYDP) (program objectives memorandum/budget estimate submission) and extended planning annex. Once P^3I becomes a part of the acquisition strategy, failure to fund it will be considered a major change in program direction.

FIGURE 3
P³I Acquisition Concept



A Cultural Change Required

The concept of P³I will require a cultural change—P³I is not the reactive conventional product improvement or "block mod" program, with which we are all familiar. These conventional programs responded to identified needs to fix system problems in the field after the systems were fielded. The M60A1 was improved by adding a thermal shield to the main gun, changing the range finder from a coincidence to a laser version, installing a solid state computer, and adding a wind sensor to make it the M60A3.

On the other hand, the basic design for the new Army/Marine Corps light armored vehicle (LAV) will integrate the space, weight, and power requirements for a pressurization unit to be added later, which will allow the vehicle to operate more effectively in a nuclear, biological, chemical (NBC) environment. The latter is an example of P³I and is identified in the acquisition strategy for the LAV and will be articulated to the contractors in the request for proposal (RFP). Another example of the effective use of P³I is on the Trident submarine. In the basic design, the missile tubes were constructed 83 inches in diameter, although the Trident I missile was only 70 inches in diameter. This spacing requirement was used to allow for the Trident II missile without major retrofit to the submarine.

The incentives for contractors to incorporate the critical interfaces must be articulated in the RFPs and rigorously evaluated during the source-selection process. Industry is capable of responding to P³I criteria if the perceived deterrents of competition and profit are alleviated. Currently, most RFPs address growth potential and provisions for future increases in capability. However, more often than not, the requirements for growth or system upgrade are vague. The contrac-

tors who propose significant investments to be responsive to these requirements risk losing the competition to others who give only lip service, but focus their resources on the minimum specified requirements of the RFP.

Even if system growth provisions are specified as hard requirements in the RFP, the first time the program office is challenged to lower costs or to compensate for other uncontrollable increases in cost that occur elsewhere in the program, the growth provisions are likely to be the first to be deleted. Similarly, there is a perception on the part of contractors that if they incorporate sound provisions for efficient evolutionary growth of a system, they may be opening the door for competitors. The PM can overcome these perceptions by identifying the pre-planned product improvements in the RFP and including them in the evaluation criteria with significant weighting.

Another cultural change that must occur if P^3I is to be successful is the acceptance of increased front-end system costs. Service PMs are continuously faced with pressures to minimize costs and avoid "gold plating" investments for growth provision to facilitate P^3I. Therefore, investments to facilitate later P^3I, such as additional space, weight, and cooling in a system, and their related costs, should be allowed. Communication of this emphasis needs to flow two ways—downward to service program managers and industry, and upward to the congressional decision hierarchy.

Technical Characteristics

When we think in terms of pre-planned product improvement, there are certain technical aspects that should be considered. First, the most important aspect of P^3I is modularity in weapon system design. The Navy's Standard missile is an excellent example of the practice of modularization. The Standard missile is one of the most advanced weapon systems in the field today and yet, in its external appearance, is remarkably indistinguishable from its Terrier and Tartar ancestors. From its inception in 1963, the Standard missile design retained the proven airframe, warhead, and propulsion systems of the Terrier and Tartar missiles. The guidance and controls were updated to incorporate solid-state electronics instead of vacuum tubes, and an electric drive instead of hydraulic drives. Since initial production in 1967, many product improvements in propulsion, receivers, warheads, fuzes, and midcourse guidance have been incorporated into the Standard missile without losing the basic interchangeability among major missile sections. In this manner, the Standard missile has become a family of interchangeable parts that may be configured to meet mission requirements, to keep pace with evolving threats, and to adapt the latest production and technological improvements as they occur. Without total redesign, the missile is capable of continued growth to keep abreast of the ever-changing threat.

Application of P^3I into the design of weapon systems will also increase the emphasis on standardization within families of weapons. This standardization

will evolve through increased use of the multiplex bus and federated computer systems.[3] The basic system design to accommodate growth or upgrade, provisions for space, weight, power, and cooling requirements for critical subsystems will demand rigorous configuration control and adherence to system baseline design. Thirdly, the program/project office must have a close link to the exploratory development program (6.2) and technology advanced development program (6.3A) and corporate IR&D programs with respect to the P³I supporting technology.

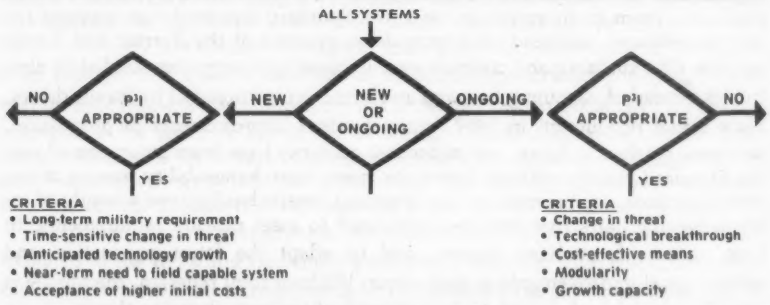
Criteria for Application

The DOD implementation plan for P³I identified several application criteria for both new and ongoing systems. Figure 4 shows some of the criteria the service PMs should consider when reviewing programs for the appliction of P³I.

Ideally, the concept of P³I should be applied to a new system at program initiation, when it can be a design mechanism in both the Concept Exploration and Demonstration/Validation phases. Development of a P³I plan as an integral part of the acquisition strategy will ensure the growth potential in the basic design to accommodate future evolutionary improvements. To accomplish this the architecture of the basic system must be sufficiently flexible to accommodate modular changes.

On the other hand, for ongoing systems, systems already in full-scale development or beyond, P³I may be limited, by the constraints of the original design parameters, to subsystem changes and/or modifications that can be incorporated without experiencing prohibitively high redesign, production incorpora-

FIGURE 4
Application Criteria



3. Multiplex bus—a circuit or channel over which several messages can be transmitted simultaneously by electronic time slotting.

tion, and retrofit costs or excessive system downtime. From a practical standpoint, P3I should be considered for ongoing systems only when the systems have a high degree of modularity and growth potential, as cited earlier in the Standard missile example. Attempting to incorporate P3I into ongoing programs where growth potential does not exist could not only create technical difficulties, but also budget perturbations for the programs.

It is important to recognize that P3I is not to be used for correction of deficiencies encountered in the basic system development. In particular, P3I should not be used as a test-and-fix technique to achieve the reliability, availability, and maintainability (RAM) specified for initial operation. Instead, P3I will be used, as appropriate, where there are legitimate technical and schedule risks that prevent proceeding with a full-capability system; it will not be used as a ruse to initiate an underfunded and/or unaffordable program.

Considerations for the PM

So far, we have discussed the background, concept, and criteria for application of P3I. Now let's discuss some considerations that will help a program manager decide whether the P3I concept is appropriate for his program. Certainly, P3I it not appropriate for all systems. Figure 5 shows the pros and cons the service PMs must consider in reviewing the application of P3I.

Pre-planned product improvement will reduce the amount of time and engineering required to initially field a system, but will increase non-recurring costs owing to the continued engineering development of system upgrades after production of the basic system. The requirements for space, weight, power, cooling, and other such provisions to provide for integration of system upgrades will, by necessity, drive the design configuration of the basic systems and increase the complexity of configuration control of both the basic systems and critical subsystem upgrades. The basic system design will have to include growth provisions for space, weight, and power requirements.

FIGURE 5
PM Considerations

CONS	PROS
—Increased non-recurring cost	—Earlier system IOC
—Space, weight, and power requirements	—Reduced development risk
—Configuration control complexity	—Potential subsystem competition
—Funding visibility	—Enhanced field performance
—Parallel R&D and procurement	—Laboratory and IR&D stimulation
—Logistic support of additional hardware	—Increased effective operational life
	—Decreased logistic support of "cutting edge" technologies

P3I will increase funding visibility because the resources to accomplish P3I will be identified during the PPBS cycle and placed in the FYDP. This increased visibility will cause decision-makers to take a hard look at programs, and should decrease "gold plating." However, it also gives the decision-maker the opportunity to trim out a part of the program and use the funds for some other purpose. This is a potential threat to the PM. The application of the concept of P3I to weapon systems will result in parallel R&D and procurement; complementary 6.2 and 6.3A research and development efforts will be required to support the development of system upgrades, unless the actual development of the advanced technology is delayed in the P3I plan.

The concept of P3I should reduce technological risk and allow for earlier deployment of supportable systems. An example of this is the Stinger anti-aircraft missile, which is being fielded with a reduced capability. Subsequent integration of the Post Seeker will bring the system to full design capability. Managing the interfaces between the primary and critical subsystems, if done well, could increase the opportunity for subsystem competition. The linkage between technology-based programs and operational requirements should stimulate the laboratories within DOD, as well as the independent research and development (IR&D) within industry. Additionally, P3I should reduce the logistics support burdens caused by dependence on "cutting-edge" technology. Usually it is more difficult to support an advanced-technology system because we are very low on the learning curve, and often systems are debugged after they are fielded. Further, the repair and maintenance data base for unproven technologies is marginal, at best.

Lastly, P3I has the potential to increase the effective operational life of a weapon system. Enhancement of system capability at specific times in the system life is scheduled, programmed, and budgeted for in the P3I plan. Use of P3I may in fact negate the need for a follow-on system if the existing system can be effectively improved.

Status of Implementation

The services have complied with the directions in the P3I implementation plan, and provided OUSD(R&E) with lists of candidate P3I systems and identified focal points. The concept of P3I has been promulgated in the revisions to DODD 5000.1, "Major System Acquisitions," and DODI 5000.2, "Major System Acquisition Procedures." The following is an extract pertaining to P3I taken from the draft revision to DODI 5000.2.

> *Pre-Planned Product Improvement.* The concept of Pre-Planned Product Improvement (P3I), the orderly, time phased introduction of incremental system capability to accommodate projected changes in threat or to reduce risk in initial fielding of the system, will be employed as an integral part of the program acquisition strategy. P3I is ideally applied to new programs.

> However, it is equally applicable to ongoing systems, i.e., those in development or being produced for inventory. P^3I modifications will adhere to the same system acquisition policy, procedures, budget, and milestone decision principles and constraints as the basic system. P^3I efforts should correspond to clearly defined performance levels, readiness and sustainability levels or changes in the military threat. P^3I should be pursued when it is clearly established that its application will reduce risk, acquisition time, and/or overall cost and will not be used to artificially extend the development effort or correct deficiencies encountered in attaining initially specified system performance. The basic design of the system will anticipate Pre-Planned Product Improvement (P^3I) which are identified in the military requirement documents and subsequently contained in the acquisition strategy and confirmed at milestone decisions. Provisions will include structure, space, weight, moment, power, air conditioning, and other accommodations to facilitate production incorporation and retrofit and minimize operational and logistic support disruption.

The services are likewise reviewing service regulations and making changes as required.

Summary

In summary, the concept of P^3I will afford program/project managers the opportunity to reduce total system costs and technological risks. During the development of the acquisition strategy for a system, the PM must consider P^3I application, keeping in mind the criteria for application. If he decides that P^3I is appropriate for his system, he will develop a P^3I plan and incorporate P^3I into his overall acquisition strategy. The pros and cons of using P^3I, discussed earlier, must be evaluated. In executing his acquisition strategy, the PM will be required to demonstrate unusual conviction to his program and exercise a high degree of persistence to overcome the pressures that impede the concept.

Increasing Competition in the Acquisition Process

26

John C. McKeown

To compete or not to compete is one of the most complex and difficult questions posed to acquisition managers. Many countervailing issues surround such a choice, so the ultimate solution centers on identifying those issues, evaluating their pros and cons, and making a compromise.

One of the 32 actions that make up the DOD Aquisition Improvement Program is designed to rekindle our focus on competition in the acquisition process. In a July 1981 memorandum, Deputy Secretary of Defense Frank C. Carlucci stated: "We believe that it [competition] reduces the cost of needed supplies and services, improves contractor performance, helps to combat rising costs, increases the industrial base, and ensures fairness of opportunity for award of government contracts."[1] Under the current leadership in DOD, managers at all levels are being asked to renew their efforts to maximize the use of competitive concepts. Mr. Carlucci further requested that management objectives for the enhancement of competition be established.

Discussion on competition frequently leads to concentration on cost savings or price reduction. This is due in part to the belief that free-market competition is an elemental part of the free-enterprise economic system. For DOD, the benefits of competition extend beyond just cost reduction to include stimulation of innovation not only in technological and design areas, but also manufacturing; lower unit costs; satisfactory technical performance (and also quality); and a strengthened industrial base. In order to accommodate these considerations, our definition of competition must be framed in the broadest of contexts: Competition is defined as the range of strategies, from development through production, which would permit more than one firm to offer its capability to the government. This definition encompasses the complete set of design and cost competitive considerations shown in Figure 1. The focus on the benefits of competition shifts from one of exploiting design opportunities early in development to one of attention to the final product in terms of its unit production cost and the effect on the industrial base.

For example, the Air Force FY 83 budget request has included about $55 million of the estimated $125 million necessary to develop the General Electric F101 engine as a potential competitor to the Pratt and Whitney F100 engine, which would power F-15 and F-16 aircraft in the mid-1980s and later. "The competition will be based on life-cycle costs rather than engine performance (alone),

1. Deputy Secretary of Defense Memorandum, "Increasing Competition in the Acquisition Process," July 27, 1981.

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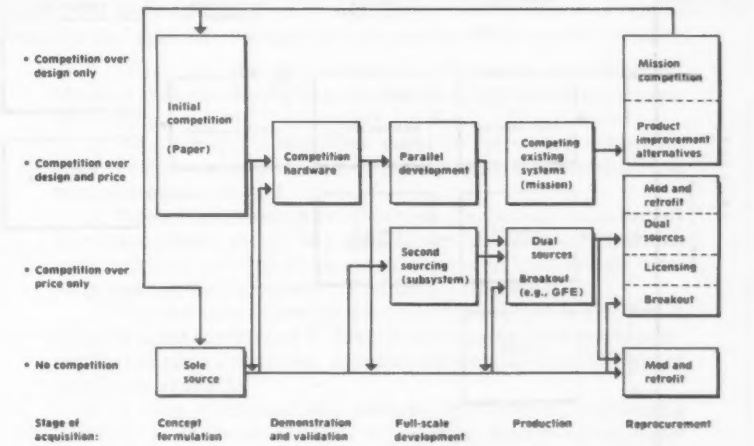
and that the strength of warranties offered by the manufacturers will be a factor."[2]

Clearly, competition is not a new consideration in DOD procurement. From the days of competitive prototyping and multiple-source production in World War II up to today, we have developed many innovative approaches to capturing the benefits of competition. However, the 1972 report of the Commission on Government Procurement made a number of recommendations on competition. Those recommendations were embodied ultimately in Office of Management and Budget Circular A-109, which was issued in 1976. A-109 not only mentioned competition in production, but also directed our attention to competition in development:

> . . . Express needs and program objectives in mission terms and not equipment terms to encourage innovation and competition in creating, exploring, and developing alternative system design concepts. . . .
>
> . . . Emphasis on generating innovation and conceptual competition from industry. Benefits to be derived should be optimized by competitive exploration of alternative system design concepts, and trade-offs of capability, schedule, and costs. . . .

FIGURE 1
Types of Competition



Source: Rand Report R-2706-DR&E, February, 1981

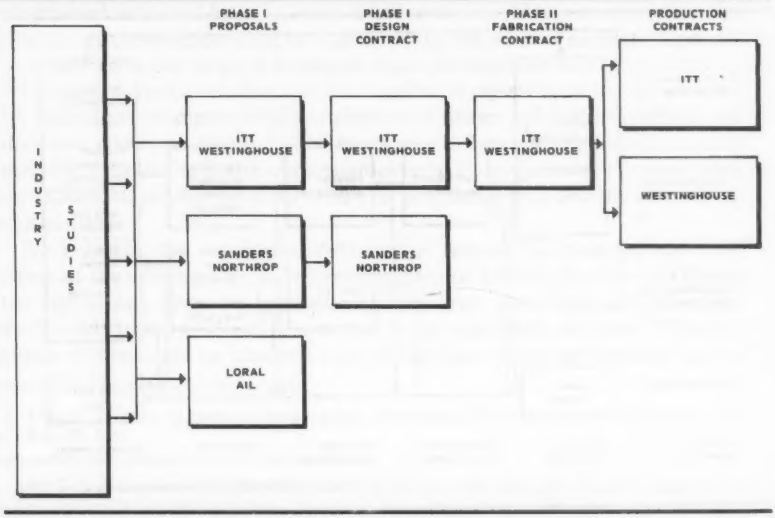
2. *Aerospace Daily*, January 7, 1982, pp. 25–26.

> . . . Providing improved opportunities for innovative private sector contribution to meet national needs. . . .

The concepts embodied in A-109 have been adopted in both DOD directives and service acquisition regulations. Therefore, OMB Circular A-109, DODD 5000.1, and DODI 5000.2 not only encourage competitive source selection, but also emphasize the active generation of competition even when it requires added near-term financial investment. Futhermore, the regulations aim at multiple development as the rule and suggest single-concept development only by exception. Consider the airborne self-protective jammer (ASPJ).

A novel competitive concept was developed to meet these objectives:
—Vitalize the industrial base,
—Focus technical talent,
—Facilitate technical change,
—Foster the "ilities,"
—Put teeth in design-to-cost,
—Lower production cost,
—Moderate production risk, and
—Reduce government surveillance.

FIGURE 2
Airborne Self Protection Jammer Competitive Teaming



Two teams of companion industrial firms *competed* for the final development and initial production contracts; for later production, however, the winning design team will be split, and then independently compete during the production phase of the acquisition (Figure 2). In this novel approach, the difficulties in establishing a second production source are overcome by having two firms intimately familiar with the design. "Cost performance and logistics support will decide who gets the lion's share of the production run."[3]

If everyone apparently embraces the concept of competition, why all the attention? Competition means many things to many people, or as Don Price of Harvard University put it: "Where you stand depends on where you sit." From the congressional standpoint, production price competition seems to be the dominant focus; in the development community, design competition is sometimes the paramount interest; on the production side, multiple suppliers are a consideration; from industry's perspective, opportunities and/or barriers to competitive consideration are a concern, to mention a few. "There is no problem in identifying defense programs to which the dual-sourcing concept should be applied. However, the two problems—that it takes a few more dollars on the 'front-end,' and that 'It's not the way the government has always done things'—are high barriers. They take courage and initiative to overcome. But the historical data are clear—costs go down and quality goes up when real competition is used."[4]

The General Accounting Office (GAO) also has expressed interest in DOD competition. The GAO observed a decline in price competition over the past several years and suggested a series of questions concerning non-competitive procurements that program managers or contracting officers might consider:

> 1. What are the procurement's minimum requirements? Material evidence should be presented verifying these minimum requirements.
> 2. What unique capabilities does the proposed contractor possess which makes it the only company capable of meeting these minimum requirements?
> 3. Was a market search or other type of solicitation conducted? Material evidence should be presented verifying that such a search was conducted and that the proposed contractor was the only company meeting the procurement's minimum requirements.
> 4. Was the item or service previously procured? If yes, was it from the same contractor? If this is a continuation of a previous effort by the same contractor, demonstrate why no other sources of supply are available.
> 5. Is there a technical data package, specification, engineering description, statement of work, or purchase description available

3. *Government Executive*, July, 1980, pp. 24–25.
4. Dr. Jacques S. Gansler, "Defense Spending: How About Some Real Competition," *The Washington Post*, April 4, 1982.

which is sufficient for competitive procurement? If not, is one being developed? If not, why not? How much lead time would be required to develop it? Has any cost-benefit analysis been conducted to determine whether it is advantageous to the Government to buy or to develop such information? If not, what evidence is available to demonstrate why this analysis is not needed?

6. Can individual components of the procurement be competitively procured? If so, what steps have been taken to do this?

7. Does the procurement result from an unsolicited proposal? If so, who first described the problem to be addressed by the unsolicited proposal? Demonstrate why the proposed contractor is the only one capable of performing the service or providing the item.

8. What material evidence exists that the Government would be injured if the non-competitive procurement is not made? This includes estimates of additional costs incurred and criticality of schedules (including when the procurement need was first identified, reasonableness of delivery schedules, etc.).

9. What steps are being taken to foster competition in subsequent procurements of this product or service?[5]

The Department of Defense is committed to introducing as much competition into the acquisition process as is possible; DOD Directive 5000.1 of March 29, 1982, requires it: ". . . Effective design and price competition for defense systems shall be obtained to the maximum extent practicable to ensure that defense systems are cost effective and are responsive to mission needs. . . . It is generally desirable to maintain design competition up to the Milestone II decision point, or beyond, if it is determined to be a cost-effective acquisition strategy." When employed properly, competition can assure fairness, avoid favoritism, obtain lower prices, and achieve better performance. Failure to obtain competition for government contracts may result not only in a loss of these benefits but in a loss of confidence in the integrity and quality of the acquisition process. Such losses could have an effect on the ability of the DOD to carry out its assigned responsibilities. As stated in the Deputy Secretary's July 27, 1981, memorandum:

> Competition can be obtained only be meticulous planning and by the support of management at all levels. It involves all functional disciplines associated with the acquisition process—not just the procurement or contracting function. Special techniques for enhancing competition have been developed for different commodities and services. Some require additional early funding to achieve significant savings in later phases. Technical or design competition may supercede price considerations during advanced or

5. GAO Report PLRD-81-45 of July 29, 1981, "DOD Loses Many Competitive Procurement Opportunities."

> engineering development phases for new equipment. Competition should be extended to the extent possible beyond initial acquisition and should include life cycle costs.

For 42 of the 48 major weapon systems reported to Congress in Selected Acquisition Reports (SARs), the contractor was picked through a competitive source-selection process, with the remaining six not having been directly competed for good reason: Only one shipyard could build the CVN-71 nuclear carrier; only a 747-sized aircraft could carry the equipment for the advanced airborne command post; and the CH-47 modification program could be done most cost effectively by the original helicopter contractor. In 24 of the SAR systems two or more competitors were under contract for some or all aspects of the development program. In some of these systems, like the F-16 and A-10 aircraft, the advanced attack helicopter, and the M-1 tank, competitive hardware was built for evaluation before entering full-scale development. In others, such as the multiple launch rocket system (MLRS), DIVAD gun, and cruise missile, DOD carried the competition through the entire development program.

For the MLRS project, competition was the means to meet DOD and congressional objective of reducing the time required to develop, produce, and deploy the system. Competition was conducted during the validation phase, with two contractors (Boeing and Vought) selected for the prototype development effort. Development and fabrication of prototypes and scored testing were accomplished between the two contractors to facilitate selection of a prime contractor for the maturation/initial production base. A second source contractor will be chosen and qualified while the prime contractor is producing the first four increments of rockets. The first buy from the second source will be a small "educational" quantity, and, if successful, it will be followed by the exercise of an option for a much larger quantity. An award will be made to each source (initial and second) for the FY 85 buy, based on cost considerations. For 1986, selection will be based on a multiyear procurement for the remainder of the program (to satisfy domestic requirements, this award is expected to be in excess of 200,000 rockets).

Even in the case of a sole-source prime development contract, significant competition still takes place at the subsystem and vendor levels for much of the effort. Currently, several systems employ production competition at the prime and subcontract level, with plans to add more in the future. In some cases, production subsystems are broken out for direct purchase by the government. For instance, the Tomahawk cruise missile has, or will have, competition managed by the program office for virtually every major subsystem.

Beyond the notional aspect of competition, however, there is plenty of room for discussion (or debate) in aggregating data to show our performance in meeting goals for competition. Do we develop a score card based on the number of competitive awards compared to the total number of contracts awarded? Or, do we compute our score based on the dollar value of those contracts? Is it proper to consider both price and design technical competition in the same data base?

And what about the situation in which we elect to go sole source after competitive development? What if there is only one supplier available in the marketplace, as in some cases in ship construction? There is not a simple answer to this challenge; the only practical, clear approach is to employ the statistical data, not as an absolute measure in its own right, but as an instrument of communication in showing progress toward our ultimate program goals. To that end, we could clarify the extent of competition in the procurement data base by simply improving our bookkeeping. The GAO has suggested that a more appropriate way to record non-competitive contract awards would be to further break the information into two separate categories entitled, "non-competitive, potential" and "non-competitive, no-potential." The DOD is giving serious consideration to adopting this recommendation.

The DOD commitment of maintaining competition in the acquisition process notwithstanding, there are some practical limits to increased competition for major systems. For some programs there are not sufficient contractors to compete effectively (in shipbuilding and certain high-technology areas, for example). In other situations, there are substantial near-term obligations in sustaining an additional competitor in either system development or production; or there can be personnel constraints, budgetary demands, initial capital investment requirements, or less-than-cost-effective production quantities that could offset competitive considerations.

On the other hand, many studies of the defense acquisition process have shown that overemphasis on competition can increase the tendency to "buy-in." Frequently, contracts are awarded to the lowest cost offeror, even though in-house estimates show little realism in such a proposal. Sometimes, our use of the "best-and-final" offer strengthens industry's perception that the final decision is based on cost, and subsequent competitions are reduced to technically leveled "auctions."

Several important actions aimed at making more effective use of competition have been completed, and others are under way. The military services and Defense agencies have been requested to:

—Designate advocates for competition at each procuring activity;
—Establish goals for increasing competition;
—Ensure commanders understand their responsibilities with regard to competition;
—Make competition a matter of special interest; and
—Develop procedures to identify and elevate significant achievements.

The Office of the Under Secretary of Defense for Research and Engineering has engaged Logistics Management Institute (LMI) to conduct a study to determine those commodities/programs offering the greatest opportunity for increased competition and those commodities/programs offering little or no opportunities for increased competition (e.g. nuclear aircraft carriers). The target

date for completion of the study is June 30, 1982.

At the direction of the Deputy Under Secretary of Defense, Defense Acquisition Regulation (DAR) coverage for the spare parts breakout program is being developed by an *ad hoc* committee chaired by the Army.

These actions are part of a broad-based program directed at obtaining more competition in defense procurement. Competition is an elemental part of our economic system; it assuredly offers opportunities for lower prices, innovation, and a strengthened industrial base. The "bottom line" for our increased focus is to maximize the use of competition when it makes sense; so let's not use it solely for cosmetic purposes. After all, the end product of our efforts is improved readiness (or preparedness, if you prefer) by providing the best possible equipment, at the most economic price, in the shortest time.

Improving the Source Selection Process

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Manfred J. Reinhard

In making its assessment of the defense acquisition system, the Carlucci-chartered action team identified as one of its concerns the shortcomings in the source-selection process. The team felt that in some past selections, too much emphasis had been placed on the lowest *proposed* costs without adequate considerations being given the contractors' records of past performance, the realism of their schedule predictions, or the credibility of their cost estimates. As evidence of these shortcomings the team noted that, in some cases, contractors have failed to perform as expected even after having been subjected to the formal, competitive source-selection process. While there are myriad factors (many of which are unrelated to the selection process) that can contribute to a contractor's failure to perform, the team was convinced that improved source-selection procedures would both encourage contractors to submit more realistic proposals and improve the government's ability to discriminate between the unrealistic and the realistic proposal. As a result, the action team made the following recommendation to Mr. Carlucci on March 31, 1981:

> Improve the source-selection process to place added emphasis on past performance, schedule realism, facilitization plans and cost credibility. De-emphasize the importance of lowest proposed cost. Devote more attention to evaluating contractors' performance during and at the time of contract completion. Provide award fee contract structure to encourage good performance. This both provides an incentive for good performance, and a measure of contractor performance to be used in future source evaluations. Establish quality ratings where possible and ensure these past performance ratings are available for use by source-selection personnel.

In his memorandum of April 30, 1981, Deputy Secretary of Defense Carlucci identified this issue as Action 20, entitled, "Improve the Source Selection Process." In this document, Mr. Carlucci directed that the following actions be taken.

> That the Under Secretary of Defense for Research and Engineering (USDRE) modify the source-selection directive, DODD 4105.62, to emphasize the objectives stated above (in the recommendations). That USDRE establish a DOD system for recording, documenting, and sharing contractor performance.

A working group chaired by a representative from the Office of the Under Secretary of Defense for Research and Engineering (Acquisition Management) and made up of representatives from the Army, Navy, and Air Force has met

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several times to implement the actions directed by Mr. Carlucci. In the process of developing their implementation approach, the working group accumulated information that should be of interest to the acquisition community at large. This information will be presented in this section under the following topical areas: (1) review of the existing source-selection directive to identify deficiencies relative to the action assignment; (2) factors that influence how past performance can be used in source selection; and (3) systems to collect and provide information on contractors' performance.

Review of DODD 4105.62

The working group found that the objectives of most of the recommendations contained in the April 30, 1981 memo are currently addressed to some extent in the existing source-selection directive. For example, the directive provides in part that:

> The prime objectives of the process are to (a) select the source whose proposal has the highest degree of realism and credibility. . . .
>
> . . . Prior to the issuance of the solicitation, a Source Selection Plan shall be approved by the Source Selection Authority. . . . In developing the [evaluation] criteria, a proper balance shall be established among technical, cost, schedule, and other factors.
>
> Proposals unrealistic in terms of technical or schedule commitments or unrealistically low in cost or price will be deemed reflective of an inherent lack of technical competence . . . and may be grounds for rejection. . . .
>
> . . . Past performance of each competitor, when it is relevant to the anticipated procurement, should be a factor in the selection decision to the extent indicated in the solicitation.

The only areas of the recommendation not already addressed in the source-selection directive are the use of award fees in the contract to encourage good performance, and the consideration of the contractor's facilitization plans during the selection process. These areas are, however, covered within the Defense Acquisition Regulation (DAR) (e.g., DAR 3-405.5, Cost Plus Award Fee Contract; 3-808.2, Weighted Guidelines Method; and 3-808.4, Profit Factors).

Factors Influencing the Use of Past Performance

LEGAL REQUIREMENTS

The Armed Services Procurement Act (10 U.S.C. 2301 *et. seq.*), provides for the award of contracts to *responsible* prospective contractors only. The Defense Acquisition Regulation, at 1-903, provides minimum standards for determination of contractor responsibility. These standards include a ". . . satisfactory record of performance. . . ." Contracting officers are required to make an affirmative determination that a prospective contractor is responsible. The signing of a contract constitutes such a determination.

In the case of a contract to be awarded as a result of formal advertising, the Comptroller General has ruled that the contracting officer is required to make awards to the lowest responsible bidder, and in the absence of a determination that the low bidder is not responsible, the contracting officer has no authority to award contracts to other than the low bidder. This entire discussion assumes that the bidder is responsive.

In the case of a contract negotiated pursuant to any of the 17 exceptions to the Armed Services Procurement Act requirement for formal advertising, the Comptroller General has found that the flexibility inherent in the concept of negotiation permits an award to be made to the best advantage of the government, and that other factors may result in an award of one offeror as opposed to another, less-qualified offeror submitting a lower price.[1] "Other factors" may include those related to responsibility. However, when the only factors to be used (other than price) relate to responsibility, an award may not be made to other than the low, responsible offeror.[2] It was apparent to the working group that care must be taken not to confuse past performance as an evaluation factor to be used in a formal source selection with the determination of a contractor's responsibility, which is required prior to the award of any contract.

Because the contracting officer's flexibility is bounded by legal constraints, a question might be raised as to whether the law should be changed. Some industry representatives have been recently quoted as favoring greater consideration of past performance in source selection. These people tend to be associated with a few large defense contractors, and their recommendations have not addressed legal requirements. This raises two issues. First, competition has recently been reaffirmed by the Deputy Secretary of Defense as the cornerstone of the entire DOD procurement system. If a recommendation were to be made to change the law, the changes would have to be such that past performance would not become an entry barrier for firms that are not already well-established DOD contractors. Second, for a contractor to be found non-responsible, there must be sufficient clear and unequivocal evidence to substantiate the determination and sustain it in a challenge through the courts. Furthermore, the contractor must be given due process if the government prevents him from competing for contracts. It would appear that any law that would abridge a prospective contractor's right to compete, other than the requirement that he must be responsible, would bring into question the integrity of the procurement process as it now exists.

The ramifications of considering past performance in a context other than responsibility determinations are further discussed below. However, as previously noted, it appears unlikely to the working group that past performance would legally be upheld as a reason not to award a contract unless the prospective con-

1. McBride and Wachtel, *Government Contracts Law, Administrative Procedure*, Vol. 1B, Para. *9.10[8], p. 9-39.*
2. *Ibid*, p. 9-42.

tractor were found to be non-responsible. Past performance is generally used in conjunction with other factors such as design approach or the quality of a contractor's management proposal. For instance, if a contractor proposes a design approach with which he has had no experience, the technical risk inherent in his approach may be considered so high by the proposal evaluators as to warrant his elimination from the competitive range. Under the proposed approach it should be noted that the determination to drop the proposal is made on the basis of the technical evaluation factor, and not past performance *per se*.

RECENCY AND RELEVANCE OF PAST PERFORMANCE

Other factors that certainly influence the usefulness of past-performance information in making a source selection are both the recency and relevance of that information. A dearth of information concerning past performance is almost never a problem for the purchasing office. The crux of the matter is whether the available information is recent enough and, particularly, whether it is relevant to an assessment of what the *expected* performance is likely to be. It is essential to understand that the "debarred list" (the Joint Consolidated List of Debarred, Ineligible, or Suspended Contractors, which will be described later) is legal only because its intent is not punitive, but rather to protect the government's interest by assuring that contracts are awarded only to responsible contractors. Similarly, any other evaluation of past performance under current laws must always have as its objective the determination of what the contractor's future performance is likely to be. It is the working group's opinion that it cannot be used to punish or reward past performance by the withholding or award of a contract.

With regard to the recency of past performance information, perhaps a few simple hypothetical examples could shed some light on the judgmental considerations involved. Suppose that Contractor X, who is being considered for a major new development contract, has a generally satisfactory record of performance as a prime and as a subcontractor, but performed poorly in his last major development contract (comparable in scope to the prospective one) about 5 years ago. Or, conversely, let's assume that his recent performance record is spotty, but that his last major effort 5 years ago was a shining success story and exemplary in all respects. How should such past performance be assessed? Unfortunately, the advocates of "doing business only with those organizations which have served you well in the past" often neglect to discuss the fact that corporations may be persons in the legal sense and may be in existence for long periods of time, but they are represented by management and other employees who come and go. This is not to say that organizations do not exhibit discernable characteristics. However, the complex interplay of the people who make up an organization is anything but susceptible to accurate predictions of what the organization may do in the future under uncertain circumstances based on what it has done in the past. In addition, organizations can change for the better or worse, just as individuals do.

This brings us to the other major issue concerning past performance—its relevance in estimating future performance. The structure of the proposed performing organization, i.e., the role of the prime contractor, his subcontractors, and materials suppliers outside the profit center, obviously determines to some extent past performance that will be considered relevant. For instance, if the prime contractor proposes to act as systems integrator only, his past performance in other roles (such as being a major subcontractor responsible for the in-house design and production of an end item) may not be relevant.

In another example, an electronics firm may have an outstanding record of assembling black boxes that are capable of being stored for prolonged periods under various conditions and be capable of performing as intended with a high degree of certainty on a one-shot basis. This contractor's excellent record may or may not be a good predictor of how he could perform under a contract that calls for another electronic assembly that is required to function in a different mode, e.g., intermittent or continuous operation over extended periods of time, under various conditions, with specified mean times between failure and scheduled maintenance actions. Both electronic assemblies may require like components, but unlike skills in their design and production.

The more esoteric the military item to be produced, the more likely it becomes that, even in a country the size of ours, success or failure may depend on small groups, or even individuals, with particular skills in technical areas or in management. Recognition of this fact has lead NASA and DOD to use the so-called "key personnel clause," which requires the prospective contractor to identify those persons whom he considers key performers and commits him to notify the government of any change in key personnel.

The value of this clause is that it permits assessment of specific past accomplishment, and that it commits the contractor to making available the personnel with whom he "sells" his proposal in the performance of the contract, if it is awarded. However, a contractor cannot guarantee continued availability of any person in the performance of a contract. Also, a contractor cannot be expected to exclusively commit key personnel to one proposal and await the outcome of proposal evaluations for months before he commits them to another. If he does propose key personnel for more than one contract and he is successful in obtaining more than one award, it may be difficult to balance the requirements for his key personnel's services.

Other "lessons learned" from the past include the realization that contractors who are skilled in advancing the state-of-the-art in science and technology (or at least in certain special areas) sometimes have a poor record of producing on time and within original cost estimates. In other cases, a contractor may be an excellent developer, but experience great difficulty in making an end item producible in quantity, or in establishing and maintaining a quality control system that will be effective in assuring successful performance over time. For certain military equipment, the nature of the work and the structure of the industry may be such

that there are only a few (or perhaps only one) viable candidates for an award. It is obvious that an acquisition strategy has to be developed long before the source selection, or even the issuance of a request for proposals, to take into consideration the unique circumstances of the acquisition being planned and to ensure that the program structure includes development and subsequent production plans.

A second crucial ingredient for a successful acquisition program is the maintenance of a reasonable degree of stability, with changes being limited in quantity and scope and restricted to the beginning of a new phase of the acquisition process, e.g., full-scale development. Changes introduced by the government in a past contract can make it difficult to ascertain who was responsible for poor performance under that contract. It matters little whether the changes were necessary or not: The fact that they occurred blurs the degree of the contractor's responsibility for poor past performance.

Systems to Collect and Report Past Performance Information

The working group also reviewed the services' experiences with using past contractor performance as a consideration in source selections. This review led to the conclusion that DOD components should be encouraged to consider past contractor performance, but that USDRE should *not* establish a central DOD system for recording, documenting, and sharing contractor performance data. Just such a system, known as the DOD contractor performance evaluation (CPE) program, was established in the early 1960s. The program was initially applied to large dollar-value development and production contracts. Subsequently, a "low dollar system" was added. The concept was to collect past performance information of specific DOD contracts and make it available to source-selection boards and officials through a data bank maintained at the Defense Documentation Center (DDC) in Alexandria, Va. In addition to source selections, the data were to be used for establishing profit/fee objectives in negotiations, for Renegotiation Board actions, and for contractor responsibility determinations.

Depending on the complexity of the contract involved, data were collected either by a program manager's narrative report describing the contractor's performance at 6-month intervals and upon contract completion, or by a "check list" type of report generated by the DOD contract administration activity. In the case of the narrative reports, contractors were given the opportunity to review and comment on the report. Each military department established a Contractor Performance Evaluation Review Group (CPERG) to review and validate program managers' and contractors' comments. Reports were then incorporated in the DDC data bank. The program was administered by a Director of Contractor Performance Evaluation in the Office of the Assistant Secretary of Defense (Installations and Logistics), who chaired a steering group with representatives from the office of the Director, Defense Research and Engineering, the Assistant Secretary of Defense (Comptroller), each military department, the Defense Supply Agency, and the Defense Contract Administration Service.

After operating for about 8 years, the program was reviewed by a Task Force on Contractor Performance Evaluation in 1970. It was found to be less than satisfactory. On December 21, 1970, after the President's Blue Ribbon Defense Panel had recommended, and the Secretary of Defense had initiated, a drive to reduce the number and volume of DOD directives, instructions, and policy memoranda, the contractor performance evaluation group was canceled. Armed Services Procurement Regulation requirements concerning the CPE Program were canceled in 1971.

JOINT CONSOLIDATED LIST OF DEBARRED, INELIGIBLE, OR SUSPENDED CONTRACTORS

Two formal methods currently in use for gathering past performance information are the Joint Consolidated List of Debarred, Ineligible, or Suspended Contractors and the Pre-Award Survey. The Defense Acquisition Regulation, in Section I, Part 6, sets forth policies and procedures for debarment (up to 3 years), ineligibility, and suspensions (up to 1 year) of firms or individuals. Contractors may be placed on the list for a variety of reasons, including conviction by a court of violations of laws, clear and convincing evidence of violation of contract provisions (including willful failure to perform, or a history of failure to perform or of unsatisfactory performance), or other causes of such serious and compelling nature affecting responsibility as may be determined by the secretary of the department concerned to justify debarment.

Ineligibility and suspension are similar in effect to debarment except that the period of time for which they are effective is generally under the control of the contractor, i.e., he may become eligible again for contract award if and when he corrects the deficiency that caused him to become ineligible or suspended. The Department of the Army is responsible for the issuance of a DOD joint consolidated list of firms and individuals debarred, declared ineligible, or suspended. The list must be used by contracting officers, and bids and offers may not be solicited from, nor may contracts be awarded to, individuals or firms on the list. The General Services Administration compiles a combined list of debarments from the individual lists of all executive agencies.

PRE-AWARD SURVEYS

The pre-award survey, as defined in Section I, Part 9, of the DAR, is a systematic evaluation of a prospective contractor's capability to perform under the terms of a proposed contract. The evaluation may be based on data on hand, data available from another government agency or commercial source, an on-site inspection of a plant and facilities, or any combination of these. Pre-award surveys can be expanded to include subcontractors, in which case the contract administration offices cognizant over the subcontractors will perform pre-award surveys and forward them to the contract administration office cognizant over the prime contractor. Although performance of the pre-award survey is the responsibility of the contract administration office, in the case of a major system

acquisition, the purchasing office can and should participate. The purchasing office can request that any or all of the following factors be investigated: technical capability, production capability, plant facilities and equipment, financial capability, purchasing and subcontracting, accounting system, quality assurance capability, transportation, plant safety, security clearance, labor resources, performance record, ability to meet required schedule, and other factors (to be specified).

It is clear that in a major system acquisition, the procuring activity can rely neither on the debarred list, nor on pre-award surveys performed by field contract administration offices for a comprehensive review of a contractor's past performance. Accomplishing such a review requires that the contract administration office and the procuring activity pool their expertise. Normally, the contract administration office will have much more detailed and better information concerning a contractor's overall operations (accounting systems, purchasing activities, etc.), whereas procuring activities will be much better equipped to evaluate the technical requirements of the work to be performed.

Conducting pre-award surveys is not the only way to identify relevant work performed by a contractor in the past. Requests for proposals for large and complex procurements frequently include a requirement that prospective contractors identify contracts they consider relevant to an assessment of past performance. Sometimes, contractors are even asked to include a self-appraisal of their performance. The merits of the latter technique will not be debated here. Suffice it to say that an identification of other pertinent contracts in a proposal provides a convenient starting place for past performance evaluations as part of a pre-award survey. Contracts a contractor may not wish to list can always be added by the contract administration office. Procuring activities should always contact at least a sample of procuring contracting officers and program managers on prior contracts to get an indication of a contractor's performance. The scope of such investigations must be consistent with the work to be performed under the prospective contract.

Future Actions

The primary future activity of the working group will be a revision of DODD 4105.62, "Selection of Contractual Sources for Major Defense Systems." Although the current version of this directive already requires the evaluation process to include consideration of past performance and the realism and credibility of cost and schedule estimates, the revised directive will place added emphasis on these factors.

USE OF PAST PERFORMANCE

With respect to past performance as a factor in proposal evaluations, the directive will be revised to encourage the use of the recent and relevant past-

performance data that would have a bearing on the government's estimate of probable future performance under the proposed contract. This is different from the determination of responsibility discussed previously in that the data used are specifically tied to identifiable elements of the proposal and are used to estimate future performance regarding that element. The sum of all elements then results in an overall risk assessment. For example, if a proposal for a new missile is evaluated, the technical factor may be broken down into guidance and control, propulsion, and warhead. Past performance can be ascertained with respect to each of these subsystems, and a judgmental risk assessment should be possible when the proposed technical approach in each area is compared with the offeror's past successes or failures. Similarly, the management approach regarding reliability and maintainability or design-to-cost should be capable of being compared to past successes or failures, once again resulting in a risk assessment on elements of the management proposal.

As previously indicated, there are currently no plans to return to a centralized system such as the CPE to collect performance information. Experience has shown that the returns for imposing such an elaborate system do not justify the costs. Rather, emphasis will be placed on the informal transfer of relevant information. One such method of transferring information on contractor performance is by making more extensive use of the pre-award survey. In addition, requests for proposals can require the contractors to include with their proposals a list of current or recent contracts. Program managers and contracting officers will be encouraged to make direct contact with their counterparts on such other contracts and pursue past-performance information to any depth they consider necessary to arrive at a reasonable judgment regarding the risks inherent in a proposed approach. This method of collecting recent and relevant past performance data is preferable to any systematic gathering and sorting of information in that it is a "management by exception" approach, which collects data only when needed and in the amount required to form a judgment.

SUBJECTIVITY IN SOURCE SELECTION

The forthcoming revision to the source-selection directive will also take into account some changes required quite apart from the recommendations contained in the Deputy Secretary of Defense memo of April 30, 1981. For example, the current issue, published in January 1976, provides for a test of the four-step source selection process, which has since been incorporated in the DAR. In addition, it appears to me that we have the opportunity to make a beginning toward reversing a disturbing trend that has been developing over the years: Contracting officers seem to have become more and more conservative because of the ease with which an unsuccessful offeror can lodge a protest. In response to this, and in an effort to increase objectivity, source-selection criteria have become more numerous and detailed—so detailed in fact, that we may fast be coming to the point where the method begins to overshadow the objective. This results in more

paperwork but, unfortunately, not necessarily in better source-selection decisions. In fact, a scored decision tree that goes out to the minor-component level in the technical factor of a set of source-selection criteria may serve to bring about an averaging, where high and low scores at the component level cancel each other out to the point where discrimination between a good and bad proposal becomes a matter of 10 points on a scale of 1,000.

Perhaps the time has now come to nudge the pendulum in the opposite direction. This new direction will allow competent professionals in contracting, cost analysis, and technical areas more room to exercise judgment, rather than proliferating both proposal preparation and proposal evaluation time and paperwork, which purports to arrive at a more objective decision, but may actually result in poorer selections. Of course, a danger with this approach is that unsuccessful offerors may view a less-quantitative selection as a "less-fair" selection and, through the excessive use of the protest procedure, force a return to the quantitative approach. However, it appears to me that the potential benefits of better selections and reduced paper work for both the prospective contractors and the government are significant enough to warrant trying this approach.

Summary

The forthcoming revision to the source-selection directive will address the shortcomings in the current process (emphasis on the realism and credibility of cost and schedule estimates and expanded use of past performance) as noted by the original action team chartered by Mr. Carlucci. In particular, program managers, contracting officers, and source-selection personnel will be encouraged to informally gather and transfer recent and relevant performance data as necessary to assist in forming an assessment of the risk associated with each scored factor in the contractor's proposal. Further, it is anticipated that the revised directive will provide for a renewed approach to the source-selection process—an approach that makes full use of the experience and knowledge of the source-selection team rather then basing the selection solely on the results of an elaborate scoring system. The revised directive, incorporating all the changes noted above, was expected to be provided in draft form to the services by June 1982. Formal reissuance of the revised directive is targeted for September 1982.

Determining the Appropriate Contract Type

44

Commander Frank T. Meneely, SC, USN

Columnist George F. Will recently wrote:[1] "Government, like life generally, is an inexact science, and its patron saint should be the stationmaster who, when asked when the train was due, said: 'That depends.'

" 'What does it depend on?'

" 'That, too, depends.' "

If that vignette were rewritten with the contracting officer being asked, "What is the appropriate type of contract?" the same retort would still apply.

Selecting the appropriate type of contract is an issue that evokes a great deal of emotion. The reason this issue commands such attention at all levels of management in both government and industry is that the type of contract dictates the pricing arrangement and defines the financial risk assumed by each party —and *everyone* is concerned about the financial arrangement!.

The purpose of this paper is to explore this issue as it relates to systems acquisition including:

—Guidelines provided to the contracting officer;

—Concerns of industry; and

—Actions taken by the DOD Acquisition Improvement Task Force.

But first, let's review the fundamentals. There are two basic families of contracts—the cost-type family and the fixed-price family. In the former, the contractor promises to provide his "best efforts," and the government promises to pay all of the contractor's allowable and allocable costs that meet the test of reasonableness. Assuming the completion form of contract, the contractor is obligated to continue performance as long as the government is willing to pay the bill. In other words, the contractor is not required to be "at risk." But, under a fixed-price contract the contractor promises to deliver a product or provide a service at a predetermined *price*, regardless of the cost outcome. In other words, at a profit if he can, at a loss if he must.

These fundamental concepts are usually clearly understood when one compares firm-fixed-price (FFP) and cost-plus-fixed-fee (CPFF) contracts, the types that define the practical ends of the contract-type spectrum. The issues, however, sometimes become clouded when incentive contracts (cost-plus-incentive-fee [CPIF] and fixed-price-incentive [FPI]) are involved. This is because the *mechanics* of these formula-type incentives are *exactly the same* as long as costs remain within the range of probable cost outcomes called the range of incen-

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1. *Newsweek*, January 4, 1982.

tive effectiveness (RIE). The fact remains that the general rules discussed above apply to *all* types of contracts within each family.

Defense Acquisition Regulation (DAR) Guidelines

Section III, Part 4, of the DAR is the bible on types of contracts. It contains the basic principles and policy guidelines concerning the selection of the appropriate contract type. Here are some salient excerpts:

> The specific type of contract should be determined by the degree of risk in contract performance. When the risk is minimal or can be predicted with an acceptable degree of certainty, a firm fixed-price contract is preferred. However, as the uncertainties become more significant, other fixed-price or cost type contracts should be employed to accommodate these uncertainties and to avoid placing too great a cost risk on the contractor. [3-401(a)(1)]
>
> The firm fixed-price contract is the most preferred type for harnessing the profit motive because the contractor accepts full cost responsibility, and the relationship between cost control and profit dollars is established at the outset of the contract. Accordingly, when a reasonable basis for firm pricing exists (see 3-404.2), the firm fixed-price contract shall be used, because its use under these circumstances will provide the contractor with a maximum profit incentive to control the costs of performance. [3-401(b)(6)]
>
> When contracting for research and development, or when price competition is not present, and (i) when the cost or pricing data available does not permit sufficiently realistic estimates of the probable cost of performance, or (ii) uncertainties surrounding the contract performance cannot be sufficiently identified to evaluate their impact on price, the use of a type of contract other than firm fixed-price should be considered. [3-401(b)(6)]
>
> The selection of contract type is generally a matter for negotiation and requires the exercise of judgment. Type of contract and pricing are interrelated and should be considered together in negotiation. [3-402(a)]
>
> The selection of the appropriate contract type is, in the final analysis, the responsibility of the contracting officer. However, because of the importance of technical considerations at the R&D stage, the choice of contract type shall not be made without obtaining the recommendations of cognizant technical personnel. Generally, the selection of contract type should also be discussed with prospective contractors. Where appropriate, R&D solicitations should permit prospective contractors to propose an alternate contract type. [3-402(b)]
>
> Cost reimbursement type contracts are preferred for all development efforts and particularly for major defense systems. When risk has been reduced to the extent that realistic pricing can occur, fixed price type contracts should be used, e.g., when a pro-

gram has reached the final stages of development and technical risks are minimal. [3-402(b)(iii)]

From this selected sampling it is apparent that the guidelines in the DAR provide the contracting officer with ample latitude for selecting the "appropriate" contract type. In fact, contrary to the generally held belief that the government has a penchant for fixed-price contracts, cost reimbursement contracts are *preferred* in certain situations. (The chart at the end of this article briefly describes each of the authorized contract types.)

The difficulty arises when the guidance is applied to a specific situation. Then the contracting officer must evaluate all of the factors or conditions peculiar to the requirement at hand, the most important of which are the nature and complexity of the statement of work (SOW), including an assessment of technical risk and the degree of confidence he has in the cost estimate. Some earlier publications even provided guidelines that directly linked the accuracy of the cost estimate to the type of contract as follows:[2]

Accuracy of Estimate	*Type of Contract*
95–100%	FFP
85–95%	FPI
70–85%	CPIF
less than 70%	CPFF

This deceptively simple test is appealing because of our affinity for numbers, but it connotes a degree of precision that is not present in so judgmental a process. While the cost estimate is of prime importance, the DAR lists several factors to be considered. These factors are as follows:[3]

—Price analysis
—The cost estimate
—Urgency of the requirement
—Technical capability and financial responsibility of the contractor
—Adequacy of the contractor's accounting system
—Other concurrent contracts

The Concerns of Industry

If the current DOD policies and regulations provide the contracting officer with ample latitude to select the appropriate type of contract, what is all the thunder about? Industry representatives do not generally find fault with the guidance, but feel that the guidance is frequently not being followed. Of primary concern is the use of fixed-price contracts in development and early production, requiring the contractor to assume a disproportionate share of the cost responsibility. The Defense Science Board 1977 Summer Study identified cost-control problems associated with development programs and stated that cost overruns are more likely to occur because of "imprecise cost estimating" than poor

2. Ralph C. Nash, *Incentive Contracting*, The George Washington University, 1963, p. 71.
3. DAR 3-402(a).

management.[4] (One of the Board's recommendations was to "Choose the contract type carefully."[5]) Industry argues that the superior bargaining position of the government enables contracting officers to limit the government's cost exposure by pushing as much of the risk on the contractor as he will accept without regard for the goal of a contract that is fair and reasonable to both parties.

Why, then, doesn't the contractor complain when such a situation arises? Industry spokesmen say that contractors are afraid of the agency reaction and potential retaliation.

These concerns were the genesis for Action 8, "Assure Appropriate Contract Type," contained in the Deputy Secretary of Defense memorandum on the subject of improving the acquisition process.[6]

Action Taken by DOD

A working group comprising representatives from the Office of the Secretary of Defense, the military departments, and industry was formed to evaluate the extent of the problem and recommend needed policy changes. Industry representatives recommended that Mr. Carlucci issue an affirmation of the DOD policy and establish an ombudsman to whom contractors could refer specific cases in which the policy was not being followed.

On January 6, 1982, Mr. Carlucci issued a memorandum to the secretaries of the military departments on this subject. In it he stated that ". . . We must always attempt to limit cost exposure not through the unreasonable transfer of risk to industry, which characteristically ends up costing the government more, but through the selection of appropriate contract forms that provide effective continuing incentives to the contractor to hold costs down." He also solicited their support ". . . in assuring that program managers and contracting officers employ the full range of their professional and business acumen in the formulation of appropriate contract type."[7]

The ombudsman's concept was, however, rejected because the highest levels of management are now involved in the development of the acquisition strategy and contract review process, and because there are existing channels of communication for industry to provide feedback.

Will all of this dialogue assure selection of the appropriate type of contract? That depends.

4. Defense Science Board Summer Study, OUSDRE, Washington, D.C., March 15, 1978, p. 68.
5. *Ibid.*, p. 91.
6. Deputy Secretary of Defense memorandum of April 30, 1981.
7. Deputy Secretary of Defense memorandum of January 6, 1982.

TYPES OF CONTRACTS

FIXED-PRICE FAMILY ← INCREASING CONTRACTOR COST RESPONSIBILITY → **COST-REIMBURS**

	FIRM FIXED-PRICE (FFP)	FIXED-PRICE WITH ECONOMIC PRICE ADJUSTMENT (FP-EPA)	FIXED-PRICE INCENTIVE (FPI)	PRICE REDETERMINATION	COST-PLUS-INCENTIVE-FEE (CPIF)	COST-PLUS-AWARD-FEE (CPAF)
DESCRIPTION	Government pays price which is not subject to any adjustment regardless of contractor's cost experience. Places maximum risk on contractor. Contractor has greatest incentive to control costs. Minimum administrative burden on parties. Preferred contract type. **Level of Effort:** Payment is based on effort expended rather than results achieved. Contractor provides specified effort over a stated period for fixed price.	The price paid by the government may be revised upward or downward if certain contingencies occur. Provides for price adjustment to protect parties against significant economic fluctuation or changes in contractor's established prices. EPA provisions can be based on established (published) prices, actual costs, or cost index. Adjustments based on established prices restricted to industry-wide contingencies. Adjustment based on labor or material costs limited to contingencies beyond contractor's control.	**Firm Target:** Government pays price that is sum of final negotiated cost and final profit. Final profit determined by comparing final negotiated cost to target cost and adjusting target profit IAW formula (share-ratio). Final price cannot exceed ceiling price. **Successive Targets:** At predetermined production point, firm target cost is negotiated and firm target profit is determined IAW adjustment formula; then either an FFP or FPI(F) can be negotiated.	**Prospective:** Government pays fixed price for goods or services for a given period, but price is subject to revision at stated times during performance of contract. **Retroactive:** Government pays price, subject to ceiling, that is negotiated after contract performance.	Government pays allowable cost and incentive fee. Incentive fee determined by comparing actual cost to target cost and adjusting target fee IAW fee adjustment formula (share ratio). Adjustment in fee is limited by minimum and maximum fees negotiated. Performance incentives should be incorporated if development is feasible and government performance objectives have been determined.	Government pays allowable cost, base fee, and award fee. Contractor earns a base fee which does not vary with performance and all or part of an award fee based on subjective evaluation by government of contractor's performance. Amount of the award fee is unilaterally determined by the government and is not subject to Disputes Clause. Evaluation of performance and corresponding partial payment of fee made at stated intervals.
ELEMENTS	Price.	Price. EPA Clause.	**Firm Target:** Target Cost Target Profit Ceiling Price Sharing Formula **Successive Targets:** Initial Target Cost Initial Target Profit Ceiling Price Target Profit Adjustment Formula	**Prospective:** Price Ceiling (Optional) **Retroactive:** Ceiling Price	Target Cost. Target Fee. Sharing Formula. Minimum Fee. Maximum Fee.	Estimated Cost. Base Fee. Award Fee.
APPLICATION	When fair and reasonable prices can be established at outset. Particularly suitable for standard or modified commercial items or military items for which sound prices can be developed. **Level of Effort:** R&D investigation or study.	When contingencies resulting from unstable market or labor conditions can be identified and covered by a separate price adjustment clause.	Where assumption of a degree of cost responsibility by contractors will provide incentive for effective cost control. Can combine with incentives on performance and schedule.	**Prospective:** Quantity production or services when a fair and reasonable price can be negotiated for initial period but not entire contract period. **Retroactive:** When fair and reasonable FFP cannot be negotiated and low value or short period of performance renders other types impracticable.	Development and test where a profit incentive is likely to provide motivation for more effective management.	Level of effort contracts for services where achievement must be evaluated subjectively. Where finite performance objectives cannot be established in advance to measure actual performance. Award fee may be used in conjunction with other types of contracts.
LIMITATIONS	**Level of Effort:** Used only when work cannot be clearly defined but effort desired can be agreed upon.		Adequate cost or pricing data must be available to establish targets; sole purpose cannot be to shift cost responsibility to government; requires simultaneous agreement on all elements of pricing structure.	**Perspective:** FFP not feasible; pricing periods conform to contractor's accounting system; and assurance that price redetermination will be taken promptly. **Retroactive:** Reasonable assurance that price redetermination will be taken promptly and requires HCA approval.	Fee limits same as CPFF.	Base Fee shall not exceed 3% of estimated cost. Maximum Fee limits same as CPFF. Weighted guidelines (for determining profit objective) shall not be applied. Shall not be used in lieu of CPFF or CPIF when objective measurement is feasible.
			Negotiated Procurements Only Adequate Contractor Cost Accounting System		Negotiated Procurements Only Adequate Contractor Cost Accounting System	

MENT FAMILY DECREASING ——→		OTHER TYPES SPECIAL USES		
COST-PLUS-FIXED-FEE (CPFF)	COST AND COST SHARING	TIME AND MATERIALS LABOR HOURS	LETTER CONTRACT	INDEFINITE DELIVERY
Government pays allowable cost and fixed fee. Fixed fee does not vary with actual costs. Fixed fee may be adjusted for changes in work to be performed. Minimum incentive for contractors to control costs. **Completion Form:** requires contractor to deliver end product (preferred form). **Term Form:** requires specified level of effort over stated period of time.	**Cost:** Government pays allowable cost, no fee. **Cost Sharing:** Government pays only a portion of allowable cost as mutually agreed to by the parties. Contractor absorbs portion of the cost with expectation of gaining other benefits from the effort.	Government pays fixed hourly rate for supplies or services with contractor furnished material provided at cost. **Labor-Hours:** differs only in that no material is supplied by contractor.	Preliminary contractual instrument which authorizes immediate commencement of effort. Method of payment corresponds to type of contract contemplated when definitized.	**Definite Quantity:** Provides for definite quantity of specified supplies or services for a fixed period with deliveries at designated locations upon order. **Requirements:** Provides for furnishing all actual requirements of specified supplies or services during a specified period as ordered by designated activities. **Indefinite Quantity:** Provides for furnishing indefinite quantity of specified supplies or services during a specified time but government must order a stated minimum quantity.
Estimated Cost. Fixed Fee.	Estimated cost.	Hourly labor rate. Ceiling Price.		Firm Fixed Price, Fixed Price with EPA, or Price Redetermination.
Research. Preliminary exploration or study. Development and test where CPIF not practical.	**Cost:** Non-profit institutions/organizations and facilities contracts. **Cost Sharing:** R&D efforts with either profit or non-profit contractors.	Engineering and design services; repair, maintenance, or overhaul; emergency situations.	When interests of national defense demand that work commence immediately and insufficient time available to negotiate a definitive contract.	**Definite Quantity:** Where definite quantity of supplies or services required during a specified period are readily available. **Requirements:** When impossible to determine in advance the precise quantities needed during a definite period of time. **Indefinite Quantity:** Same as requirements but government is only committed to minimum quantity.
Fee shall not exceed 15% of estimated cost for R&D or 10% of estimated cost for production contracts. Price of A/E contract shall not exceed 6% of estimated cost of the public work or utility project.	**Cost Sharing:** Not applicable for effort specified by government or which has only minor relevance to commercial activities of the contractor.	Determination that no other type of contract is suitable.	Written determination that no other type suitable. Price ceiling required if award based on price competition. Must be definitized within 180 days or prior to completion of 40% of work. Maximum government liability cannot exceed 50% of estimated cost.	
Negotiated Procurements Only Adequate Contractor Cost Accounting System		Negotiated Procurements Only		

Action 21: Standard Operation and Support Systems

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Colonel Walker A. Larimer, USAF

A prior article in *Concepts* addressed the genesis of the DOD Acquisition Improvement Program and provided an excellent overview of its 32 different recommendations.[1] The purpose of this paper is to expand the discussion in the previous article about Action 21, and explain how it can save money, enhance support, and increase force readiness. The title of Action 21 is "Develop and Use Standard Operation and Support Systems," but a more direct title might be "Let's Make Materiel Standardization Happen!"

The Environment

Down in the program offices of the military departments—where the real acquisition pick-and-shovel work gets done—many different communities are working energetically to develop and produce their respective weapon systems. These various communities contain personnel who may be described as program managers, engineers, contracting officers, logisticians, development planners, and those who represent the standardization community.

For the most part, the standardization community may be broken down into two basic parts: those who administer, develop, and maintain the military specifications, standards, policies, and associated documents; and those who enforce or control the application of specifications and standards, and make materiel standardization happen. The first group of "standardizers" within the services obtain their tasking through their respective departmental standardization offices (DepSOs). The second group of "standardizers"—far fewer in number—receive their tasking from high-level military commanders, and their scope is generally limited to a specific commodity area.[2]

All of the above communities should be working together, complementing one another as a united team with one shared objective—timely delivery of a cost-effective fighting machine in which all have significant pride. However, sometimes conflicting goals separate one or more of these communities as dramatically as those that divided the Hatfields and McCoys.

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1. Colonel G. Dana Brabson, USAF, "Department of Defense Acquisition Improvement Program," *Concepts*, Autumn 1981, Volume 4, Number 4, pp. 54–75.

2. Examples of standardization enforcers (as used in this context) are (1) The Army's DOD Program Manager for Mobile Electric Power (DRCPM-MEP); (2) the Naval Air Systems Command's Director of Core Avionics (AIR-533); (3) the Naval Air Systems Command's Director of Support Equipment (AIR-522); and (4) the Air Force's Deputy for Avionics Control (ASD-AFALD/AX).

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The Department of Defense acquisition management hierarchy extends from the third floor of the Pentagon (where centralized control of executive policy direction occurs) to the program offices in the field (where decentralized policy implementation occurs). The same issues that often divide the specialized communities in the field also divide the Pentagon's third floor. When individuals within a community perceive that their important concerns are being pushed under the rug, they tend to escalate these issues within the hierarchy of their same community. As resistance to negotiation increases between these different communities, escalation, as well as escalation tactics, increases. As the debate continues, the communities become more and more polarized, bogging down the whole decision-making and program approval process.

Disadvantages Outweighed by Advantages

Materiel standardization is a discipline that engineers understand and use as a fundamental tool in their decision-making process. Acquisition managers, on the other hand, often view standardization as an obstacle to be overcome in the pursuit of individual program goals. Standardization may, in fact, affect their program costs, schedules, or technical performance. Sometimes, the manager who first develops an item to be designated as common standard hardware or software may have to pay a little more, or may have to wait a little longer for delivery. Because his equipment will also be used on other weapon systems, it takes more time for his engineers to ensure that the requirements of the other potential users are satisfied, and that the respective weapon system interfaces are adequately defined. This extra "up-front" work provides the initial acquisition manager with no immediate benefits, but it certainly minimizes technical, manufacturing, and modification risks for the follow-on weapon system users and the logisticians. The follow-on buyers receive the items more cheaply and quickly than if they had developed and produced unique equipment for their respective weapon systems. Thus, these standardization rewards—plus higher reliability, higher quality, and improved supportability—go to the second, third, and other downstream users of the equipment standard.

Use of standard avionics architectures in a major weapon system provides the acquisition manager and the support system manager with the capability to integrate new avionics and armament subsystems in the weapon system more efficiently.[3] This, in turn, permits significantly lower modification costs, lower modification man-hours, and, therefore, quicker weapon system turnaround times. Re-engineering the force becomes practical, expeditious, and affordable, and pre-planned product improvement (P^3I) becomes a reality.

3. An example of good avionics architecture is use of the MIL-STD-1553B multiplex data bus, MIL-STD-1750A Instruction Set Architecture (ISA) in the general purpose processor(s), MIL-STD-1589A High Order Language, and MIL-STD-1760 aircraft-to-stores electrical/mechanical interface standard in an aircraft weapon system.

When acquisition managers use the hardware, software, and architectural standards, the taxpayers achieve life-cycle cost savings accruing from common (or near common):
—Spares
—Ground support equipment
—Software support tools
—Technical data and manuals
—Depot repair activities, equipment, etc.
—Training equipment, capabilities, etc.
—Organic maintenance know-how
Such savings are not accidental. They are deliberate and planned across-the-force initiatives executed by the standardization community.

Materiel standardization and Action 21 are inseparable. Program managers who exert a real effort to make materiel standardization happen will at the same time make tangible progress in carrying out several other closely related acquisition improvement initiatives such as:
—Increase use of pre-planned product improvement (Action 2).
—Increase program stability (Action 4).
—Use economical production rates (Action 7).
—Improve system support and readiness (Action 9).
—Provide contractor incentives to improve reliability and support (Action 16).
—Improve reliability and support (Action 31).
—Increase competition (Action 32).

The Action Plan

The Action 21 action plan was conceived by staff members of the Office of the Under Secretary of Defense for Research and Engineering (OUSDRE). It was proposed to the military departments in an OUSDRE memorandum dated July 10, 1981. The military departments were requested to evaluate the plan and attend a July 30, 1981, meeting at which time service positions would be expected. That meeting was held and representatives of all three military departments, plus the Defense Logistics Agency, agreed in principle with the proposal.[4]

The action plan was divided into three phases so that progress could be realized on a near-term, mid-term, and far-term basis; however, progress was and still is totally dependent upon innovation and good teamwork among all communities involved in the acquisition process.

4. In a December 1981 meeting, when a progress report on the conduct of the Acquisition Improvement Program was coordinated with the military departments prior to the delivery of this same document to the Deputy Secretary of Defense, one service stated that the previous agreement-in-principle did not represent a coordinated service position. Subsequently, all such statements were deleted from the progress report.

In Phase 1—designated specifically to permit near-term benefits—OSD selected about 15 ongoing (approved and funded) or planned (funds budgeted) tri-service subsystem acquisition programs. Most of these programs were avionics and ground support equipment (GSE) items. These commodity areas lend themselves more easily to materiel standardization than do most of the other areas. Many of these projects were originally conceived for tri-service application or multiple application in different weapon systems within a single service. Each project had its own inhibitors for real progress. These problems ranged from a lack of dedicated tri-service resources (manpower and/or funds) to tri-service disagreement on the technical approach to satisfy the operational requirements of the respective participants.

The OUSDRE listed the issues associated with each program and urged the services to resolve them so that the originally planned goal—a common hardware standard—would evolve in the near term. Hardware programs that OSD identified for Phase 1 attention included some controversial programs such as the Multi-Role Radar (MRR), Joint Tactical Information Distribution System (JTIDS), the next generation IFF system for tri-service and NATO application called the Combat Identification System (CIS), the Modular Automatic Test Equipment (MATE) program, and the jam-resistant ultra high frequency (UHF) Seek Talk system, along with its non-interoperable service counterpart.

During the July 30, 1981, meeting, each service confirmed its respective intentions to use (or not use) these programs as potential hardware standards. It is still not clear how many of these programs will actually end up as tri-service hardware standards. Even if only one service commits to the use of a program as a standard for multiple weapon system application within that same service, significant supportability and force readiness benefits accrue. These same benefits multiply if the other services commit to the use of that same item. At the July 30, 1981, meeting, OUSDRE expressed its willingness to declare these programs as "special interest" programs (providing a measure of funding stability) if the services would reach definitive agreement on the application of any equipment item as an equipment standard.

Phase 2 (mid-term pay-off) provides each service with a continuing opportunity to identify its own RDT&E or production candidates for use as hardware standards in different weapon systems managed by that same service, or by the other services. This phase requires the acquisition manager to:

—Harmonize his operational and technical requirements with those of the other services;

—Obtain agreement on the technical and business strategy approach to satisfy the requirements; and

—Agree in principle with the notion of a cooperative RDT&E program wherein all participants share and share alike in the funding.

The ease with which these negotiations take place depends on the manager's rapport with his counterparts in the other services and/or the standardization

organization structures which may (or may not) exist within the services to sponsor these negotiations. Here, as in Phase 1, OSD expressed its willingness to declare worthwhile programs as "OUSDRE special interest" if there was military department commitment to the developed item as an equipment standard. Although several different hardware programs were proposed by the services, most were not properly coordinated with another (second or third) service and, for this reason, failed to raise much interservice interest. We must now concentrate on ways to more efficiently sell and coordinate these proposals.

Progress

While total progress in Phases 1 and 2 has been minimal (at least from a quantity-of-standardization-activities standpoint), there were some very interesting highlights. For example, a noteworthy Phase 1 touchdown was scored by the Air Force when it tied the MRR program to the B-1B Long Range Combat Aircraft (LRCA). Another standardization touchdown was made in December 1981, by the Joint Services Review Committee (JSRC) on Avionics Components and Subsystem Standardization—a tri-service committee under the cognizance of the assistant secretaries of the military departments (research, development, and acquisition). This committee submitted an excellent Phase 2 proposal to OUSDRE. The JSRC's primary function is to coordinate the respective avionics RDT&E programs of each military department, and to engage in cooperative RDT&E ventures that lead to multiple-service avionics hardware standards. The strength of this committee's proposal is a direct result of having an existing management organization armed with a charter to do exactly what Action 21 urges the services to do.

The JSRC proposal addressed five different Phase 2 avionics projects. Each requires approval and funding from the respective participating services. Each represents an unfunded requirement in FY 82 or FY 83 that must be accommodated by reprogramming and/or budgeting adjustments. Although significant life-cycle cost avoidance "savings" will result, initial funding problems exist for the participants. A "lesson learned" is that the services should have specific program elements with adequate funds to provide the front-end "seed money" for hardware standardization projects. At this writing, we are waiting to see whether or not the military departments will receive the funds for this proposal

During the October-December 1981 time frame, a special task force was convened by the Deputy Secretary of Defense to evaluate the progress being made on the Acquisition Improvement Program (AIP). To obtain an objective and unbiased evaluation, personnel were selected for the task force who did not have any prior involvement in developing plans for and/or implementing the various initiatives. The two organizations responsible for providing personnel to evaluate progress on Action 21 were the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics) and the Department of the Navy. For the most part, their report on Action 21 was favorable.

Phase 2 is not limited to avionics programs. The military departments can propose standardization programs in all commodity areas. I am convinced that the reason other properly coordinated projects were not submitted is the lack of strong management organizations (such as the JSRC for Avionics) in other commodity areas. The existing departmental standardization offices within each service are designed and staffed to handle standardization *policy* matters and those activities related to the military specifications and standards documents. The DepSOs are not manned and structured to conduct activities in the conventional acquisition program sense. If Action 21 is to succeed, and it must, we will have to consider and implement remedial actions such as: (1) changing the management structure and charters of the existing DepSOs; and (2) finding ways to have our program managers and standardizers dedicate more time and effort to "hard sell" their own activities and achieve tri-service coordination.

Back to the Action Plan

Phase 3—structured to provide mid- to long-term benefits—is a continuing effort to examine existing standardization policies, regulations, and management organizations. Should deficiencies exist, we must figure out practical means to respond to them. Phase 3 involves many other complementary activities. An example is the special panel of government and industrial managers conducted at the November 3–5, 1981, DOD Standardization Seminar at Leesburg, Va. This panel recommended ways in which the government could truly incentivize materiel standardization. Another activity was the revitalization of the DOD Materiel Standardization and Specifications Board (DMSSB)—an executive-level/flag-rank group of acquisition and logistics decision-makers representing the military departments, the Defense Logistics Agency, OASD(MRA&L), and OUSDRE. The purposes of this board are to:

—Participate in formulation of centralized policy and direction;

—Provide review and oversight of the standardization process within their respective organizations; and

—Recommend standardization initiatives.

The DMSSB provides its standardization program recommendations to the Under Secretary of Defense for Research and Engineering and recommends annual standardization guidance to the military departments and the defense agencies. The board met on January 25, 1982, (the first time since 1977) and agreed in principle with the proposed CY 82 DOD standardization guidance. This guidance was disseminated to all Department of Defense organizations on March 17, 1982; however, its implementation by the military departments remains unclear. Additional activities under Phase 3 include a possible audit of the state-of-health in materiel standardization within the military departments including insertion of the audit results in the CY 82 standardization report to Congress. Phase 3 efforts include: (1) activities to monitor the military departments' compliance with the

CY 82 standardization guidance; and (2) necessary actions to strengthen the materiel standardization process at all levels of acquisition management.

There were many policy, regulation, and organizational issues reported at the November 3–5, 1981, DOD Standardization Seminar that should be addressed as part of the Phase 3 activities. These issues include a wide spectrum of areas ranging from those affecting the acquisition manager and his contracting officer to those requiring revisions to the Defense Acquisition Regulation (DAR). The December 1981 Progress Report of the Acquisition Improvement Program (previously discussed) directs OUSDRE to take the lead in resolving these deficiencies. The deficiencies are numerous and will be listed in the proceedings of the November 3–5, 1981, DOD Standardization Seminar (in printing at the time of this writing). There is enough work associated with these corrective actions to keep all of us busy for months. Progress will be slow, and instant success stories will be few and far between. The conditions currently inhibiting materiel standardization progress will require our dedicated attention. If resources are not dedicated to this effort, we may expect additional guidance and direction from the Deputy Secretary of Defense.

Success in Subsystem Standardization

It is rewarding to see positive evidence that materiel standardization is occurring at the major subsystem level. For example, the Army's program office for the Division Air Defense (DIVAD) gun has determined that it will use a derivative of the Air Force's F-16 aircraft radar fire control system (AN/APG-66) for its radar fire control system installed on the upgraded M48A5 tank. Westinghouse is the subcontractor for the radars in both the F-16 aircraft and the upgraded tank.

In a competitive source-selection process, Boeing selected Westinghouse as the contractor for the multi-role radar (MRR) system to be used in the Air Force's B-1B bomber. Westinghouse's design concepts for the MRR are strongly influenced by their radar-improvement program for the F-16 radar. Engineers estimate that from a piece-parts standpoint, there will be significant commonality among all three weapon systems (perhaps as much as 80 percent), a good degree of commonality between shop-replaceable units (SRUs), and a lesser degree of commonality between line-replaceable units (LRUs). However, there is a high pay-off for the few LRUs that are similar. For example, the high-value transmitter LRU used in the Army's DIVAD fire control system is identical and directly interchangeable with the transmitter used on the F-16 aircraft radar. The part numbers for the two transmitters are different only because the F-16 transmitter is painted gray and the DIVAD radar transmitter is painted white! However, the most significant benefit to the Army's DIVAD program manager—resulting from the decision to use the Air Force's F-16 radar fire control system—is the RDT&E cost avoidance.

What's Your Role?

What can an individual program manager do to improve DOD's posture with respect to materiel standardization? Although the concept is not new, the intensity of the current thrust may catch some by surprise. To comply with Action 21, program managers must demand that their technical staffs maintain liaison with their counterparts in other program offices within the service and among the services. Developing new equipment without knowledge of similar requirements in other services is simply unacceptable. For example, engineers responsible for propulsion in one program know the propulsion engineering community throughout Defense. But where this may not be true, there are several avenues of assistance open.

One possibility is the DepSOs discussed earlier in this article, which may not be able to identify your counterpart immediately, but which can provide you with appropriate contacts in a day or two. The DepSOs are as follows:

Commander U.S. Army Materiel Development and Readiness Command Attn: DRCMT-S Alexandria, Va. 22333	John Kicak 703-274-9830 AV 284-9830
Chief of Naval Material Attn: MAT 04342 Washington, D.C. 20360	Bernard Bland 202-692-3011 AV 222-3011
HQ AFSC/ALK Andrews AFB Washington, D.C. 20334	Clark Walker 301-981-6869 AV 858-6869
Director Defense Logistics Agency Attn: DLA-SE Cameron Station Alexandria, Va. 22314	Henry Filippi 703-274-6781 AV 284-6781

For the avionics area, the Joint Services Review Committee:

Colonel George Botbyl ASD/AFALD/AX Wright-Patterson AFB, Ohio 45433	513-255-2734 AV 785-2734
Ken Ricker ASD/AFALD/AX Wright-Patterson AFB, Ohio 45433	513-255-5694 AV 785-5694
Colonel D. D. Garrison USA-AVRADA Fort Monmouth, N.J. 07703	201-544-2922 AV 995-2922

John Respass — 201-544-4595
USA-AVRADA/DAVAA-I-SI — AV 995-4595
Fort Monmouth, N.J. 07703

Captain A. Perrella — 202-692-3965
AIR 533 — AV 222-3965
Naval Air Systems Command
Washington, D.C. 20361

Richard Meyers — 202-692-3884
AIR 533F — AV 222-3884
Naval Air Systems Command
Washington, D.C. 20361

Also, the staff of the Defense Materiel Specifications and Standards Office (DMSSO) stands ready to help. The office may be contacted by writing to:

Defense Materiel Specifications and Standards Office
II Skyline Place, Suite 1403
5203 Leesburg Pike
Falls Church, Va. 22041

or by calling 703-756-2339 or Autovon 289-2339.

Lessons Learned and Summary

Because of the escalating costs of defense materiel and services during a time period when there are countless other demands on the national budget, we should expect and prepare for future reductions in the DOD budget. There is virtually no way to fund all the worthwhile programs that DOD acquisition and support managers want. We must continue to find innovative ways to stretch our approved funds. Making materiel standardization happen is one way to accomplish this objective.

Standardization is a discipline that affects all acquisition and support programs in a horizontal sense across DOD. Materiel standardization requires a strong organizational structure—particularly a marketing and sales force—to advocate its benefits through the vertically structured acquisition management lines to the weapon system program director and his acquisition managers. Defense acquisition managers have heavy demands on their time and simply don't have the slack to market the products of their program in another program office, even if their generic needs are similar.

Maybe it is unrealistic to expect program managers to be salesmen for their programs to anyone but the Congress, the Secretary of Defense, and the secretaries of their military departments. If this be so, now is the time for us to think seriously about how we can carry out this critically important function with other program offices. Some possible options:

—Beef up the present DepSO mission and staff organization. Give them adequate resources to carry out the recent materiel standardization initiatives.
—Create additional Joint Service Review Committees (JSRCs) for other high payoff commodity areas (e.g., aircraft ground support equipment, automatic test equipment, etc.).
—Create single acquisition managers, within and for DOD, on certain types of equipment (e.g., airborne and ground radios).

While struggling with our mundane standardization management and organizational deficiencies, let us not forget the pot of gold at the end of the rainbow—the benefits of materiel standardization! If done in a smart way, it can provide the taxpayer with:
—After the first application, reduced initial acquisition costs and lead times;
—Reduced life-cycle costs across the force;
—Ease of incorporating major modifications and quicker "turnaround" times;
—Increased force readiness; and
—More reliable and higher quality subsystems and components.

As I step down off my soapbox, let me close by re-emphasizing the need for action. If we don't get our collective acts together and move out on materiel standardization in a coherent, coordinated way, the Congress, GAO, or someone else is going to force feed it to us and the results may not be as beneficial as if we heal ourselves. ‖

Controlling Murphy: How to Budget for Program Risk

60

Lieutenant Colonel John D. Edgar, USAF

General George S. Patton once said: "Take calculated risks. That is quite different from being brash." As the quote suggests, taking a risk is not necessarily bad. In fact, in both combat and weapon systems acquisition, taking risks is good, provided the risk-taker recognizes what he or she is doing and plans in advance to cope with potential adverse outcomes. The secret lies in keeping Mr. Murphy and his gremlins under control.

The only reason risk is even an issue is that people set challenging goals. In defense acquisition, there is really no alternative. The only way to remove all risk from an acquisition program is to overfund it, make the schedule too long, or set performance targets too low. It is doubtful that American taxpayers would accept that kind of planning for defense systems. Therefore, what program managers must do, as will be discussed in this article, is select program parameters that provide a reasonable level of risk, and then establish a strategy that allows them to cope with the adverse consequences they might encounter.

Background

Before proceeding, we need to define the term "risk." A typical dictionary defines risk as the possibility of loss or injury. This definition implies that risk has two components—the probability of some event occurring and the adverse consequences of that event, should it occur. Thus, to analyze risk we must be able to estimate both these factors. The first factor may be estimated in terms of some probability distribution, whereas the second factor may be stated in terms of additional dollars and time required to recover.

Risk analysis, as discussed in this article, can be divided into three parts. First, each component of the program must be analyzed to determine what uncertain events could occur, with what probability, and with what impact. Second, the component risks must be combined to arrive at the risk for the total program. Third, the result must be presented in a way that promotes understanding of the risks involved and aids in planning to cope with those risks.

Existing Department of Defense (DOD) and service policy directives clearly state that program managers should indicate bands of uncertainty in cost estimates and "include risk costs and costs of likely contingencies. . . ."[1] In the

1. U.S. Department of Defense Instruction 5000.2, "Major Systems Acquisition Procedures," 19 March 1980, paragraph E.5.c.; Air Force Systems Command Manual 173-1, *Cost Analysis: Cost Estimating Procedures*, 17 April 1972, paragraph 5-3.i(4); Department of the Army Pamphlet 11-2, *Research and Development Cost Guide for Army Materiel Systems*, 3-5.a.

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past, however, program managers who explicitly requested funds to cover program uncertainties have usually found those funds deleted by the services or DOD in the planning, programming, and budgeting system (PPBS), by the Office of Management and Budget (OMB), or by the Congress. Thus, when such adverse events actually occurred, the program manager was faced with some hard decisions. He could delay his program while trying to obtain additional funds through the PPBS or by reprogramming; or he could adjust funds internally by reducing the program scope, stretching schedules, deleting redundancy in tasks and hardware, and borrowing against the future by deleting test hardware, and reliability and maintainability tasks. Most program managers, whether they would publicly admit it or not, have responded to this problem by budgeting an undisclosed, internal management reserve. This reserve might be spread in small amounts across all the program tasks, or concentrated in the form of a single, "soft" work element that could be deleted without affecting the program.

The Acquisition Improvement Program

This failure of DOD funding policy to allow for evaluation, quantification, and open planning for risk was recognized by the working groups chartered by Deputy Secretary of Defense Frank C. Carlucci to review the acquisition process. As a result, the memorandum on "Improving the Acquisition Process," signed by Deputy Secretary Carlucci on April 30, 1981, included as Action 11, "Incorporate the use of budgeted funds for technological risk."[2] Action 11 recommended that DOD increase its "efforts to quantify risk and expand the use of budgeted funds to deal with uncertainty." The action directed all services to budget funds for risk. In addition, it tasked them to review the Army's total risk assessment cost estimate (TRACE) concept and either adopt it or propose an alternative method.

Total Risk Assessing Cost Estimate (TRACE)

The TRACE concept was initiated by the Army in 1974 under the guidance of Norman R. Augustine, then Assistant Secretary of the Army for Research and Development. The TRACE was designed to provide program managers with a disciplined method of costing for risk, while providing higher authorities with a scientific money management system. An implementing letter of instruction was published in March 1975.[3] The TRACE concept has been accepted by Congress for use in developing the Army's RDT&E budget estimates.

Before discussing the actual techniques used in quantifying the program risks, some terminology and the general management concept require explanation.[4]

2. Frank C. Carlucci, memorandum for the Secretaries of the military departments, and others, subject: "Improving the Acquisition Process," 30 April 1981.

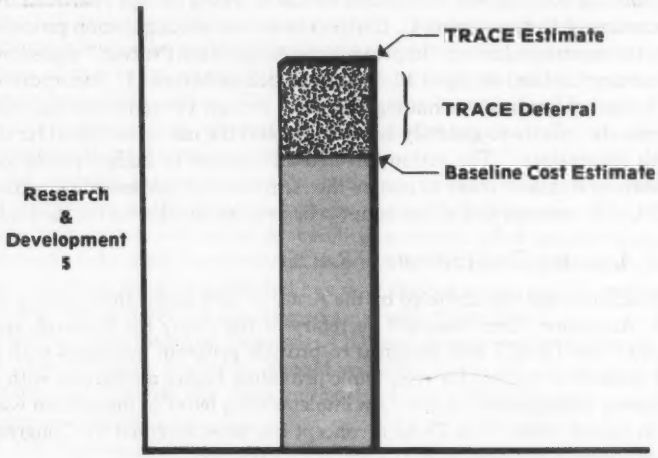
3. "LOI for Implementation of TRACE," U.S. Army Logistics Management Center, Fort Lee, Va., 6 March 1975, ALM-63-4476-H.

4. Department of the Army briefing brochure, "The TRACE Concept," undated.

Figure 1 displays the basic terms used in TRACE. The baseline cost estimate (BCE) budgets the funds required for all planned activities based on the fixed program schedule. The TRACE deferral covers a reasonable percentage of the costs that would be required to deal with forseeable project uncertainties—the "known unknowns"—that can be handled statistically.[5] The TRACE estimate is the total program cost comprising the BCE and the TRACE deferral.

Figure 2 displays the management concept under which TRACE operates. Three important points should be noted. First, the concept is only used in budgeting RDT&E funds. Second, the Army provides only one value, the TRACE estimate, in the budget documentation submitted to Congress. Third, when Congress authorizes and appropriates the program funds, the program manager receives only the BCE amount. The remainder, the TRACE deferral, is held at Department of the Army (DA) headquarters level. The TRACE deferral funds are only released to the program manager after he has submitted proper

FIGURE 1
TRACE Terminology



Baseline Cost Estimate - Funds required for planned activities
TRACE Estimate - Total cost included in budget request
TRACE Deferral - Money withheld by DA Headquarters to cover a percentage of the cost for program uncertainties

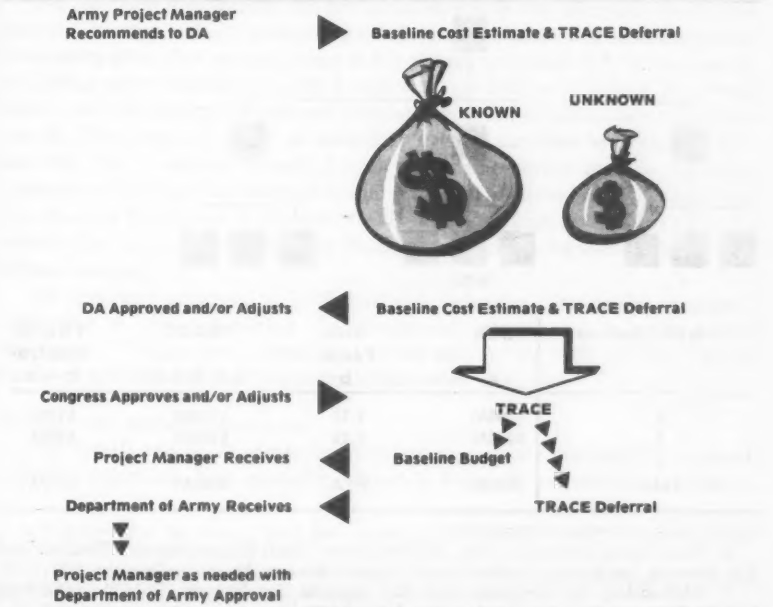
5. A reasonable percentage is normally taken as the amount which would provide an even chance (50/50 probability) of accomplishing the program within the TRACE estimate.

justification through the Department of the Army's Materiel Development and Readiness Command (DARCOM) headquarters. The funds release must be approved by both the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA) at DA headquarters and the Assistant Secretary of the Army for Research, Development and Acquisition (ASA(RDA)). Requests for release of TRACE deferral funds are normally approved in one month or less. Normal reprogramming procedures must be used if the deferral funds are transferred outside the program that originally justified them.

Methods for Computing the TRACE

There are several methods program managers may use in computing a TRACE estimate. In all of the methods, the BCE must first be computed using standard estimating procedures. Such procedures include parametric estimating based on cost-estimating relationships (CERs), or "bottoms-up," detailed engineering cost estimating, to name just two.

FIGURE 2
TRACE Management Concept



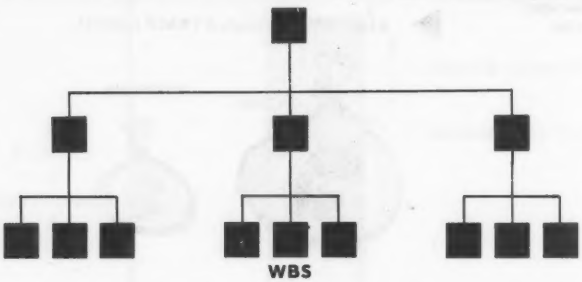
RISK PERCENTAGE APPROACH

The simplest method for computing the TRACE estimate requires minimum time and resources to apply and has been called the "risk percentage approach."[6] Under this approach the program manager applies a "rule of thumb" and merely increases the BCE by some subjectively derived percentage representing the total program risk. The program manager is not required to consider subelements of his program individually, nor to take account of possible interactions between them. This approach was used by one-fourth (5 out of 20) of the Army program management offices surveyed by the U.S. Army Logistics Management Center in 1980.

RISK-FACTOR METHOD

Moving slightly up the scale of complexity, there is the risk-factor method used by roughly one-half of those surveyed in 1980. This method can be done by hand on any program which has a work breakdown structure (WBS). Figure 3 depicts how this method operates.[7] Basically, a subjectively derived risk factor is

FIGURE 3
TRACE Risk Factor Method



WBS Element	BCE a	Risk Factor b	TRACE a × b = c	TRACE Deferral c − a
1	$100M	1.10	$110M	$10M
2	$200M	1.25	$250M	$50M
:	:	:	:	:
Total	$300M	N/A	$360M	$60M

6. Major George Schneickert, USA, and Paul Grover, "Don't Be Lost Without a TRACE—Total Risk Assessing Cost Estimate Methodologies," *Program Manager*, November-December 1981, p. 19.

7. "Methodology for Developing Total Risk Assessing Cost Estimate (TRACE)," U.S. Army Logistics Management Center, Fort Lee, Va., ALM-63-4476-H3.

assigned to each WBS subelement. Then the BCE for each WBS subelement is multiplied by the appropriate risk factor and the results summed up for all the subelements. In effect, this method computes a weighted average risk factor, which represents the contribution of each subelement risk factor weighted by the dollar value of the subelement.

PROBABILISTIC EVENT ANALYSIS

The third methodology, called probabilistic event analysis, also begins with the WBS elements, but carries the analysis one step further to consider the interactive effects of one WBS element on the other elements.[8] The end result is a calculation of the "expected value" of uncertain events, including their secondary effects.

A hypothetical probabilistic event analysis is illustrated in Figure 4. In this technique, the first step is to review all the program elements (column 1) and list all the uncertain events that could occur and have an impact on program cost or schedule (column 2). People familiar with the work then estimate the probability of occurrence of each event (column 3) and its impact on the cost of the work element (column 4). The "expected value" of each event (column 5) can then be calculated by multiplying the estimated cost impact by the event probability.

The next step is to identify the secondary effects of the uncertain events (column 6). This step includes assigning a conditional probability of secondary event B occurring given that primary event A has already occurred, P(B/A) (column 7); calculating the probability of event B occurring, i.e. $P(B) = P(B/A) \times P(A)$[9] (column 8); and estimating the cost and schedule impact of the secondary event (column 9). The "expected value" of secondary event B can then be calculated (column 10). The "expected values" of both the primary event and the secondary events it could trigger are summed (column 11) and identified with the fiscal year (FY) in which they could occur (column 12). Thus, the final result is the total "expected value" of uncertain events by fiscal year, which can be used as the TRACE deferral amount.

No programs surveyed in 1980 used this technique, principally because of "difficulty in conceptualizing the interaction effects and lack of trained analysts. . . ."[10] However, subsequent to that survey, the TRITAC AN/TTC-39 family of switches has used the probabilistic event analysis.

PROBABILISTIC NETWORK MODELING

The fourth and most demanding methodology is the probabilistic network modeling approach. This approach, shown in Figure 5, uses network models in

8. Department of the Army, "Total Risk Assessing Cost Estimate (TRACE) Guide," Contract DAAK40-79-C-0034, 1 September 1979.

9. In this case the equation $P(B) = P(B/A)P(A) + P(B/A)P(A)$ is simplified since by definition event B cannot occur without event A causing it, i.e., $P(B/A) = 0$.

10. Schneickert and Grover.

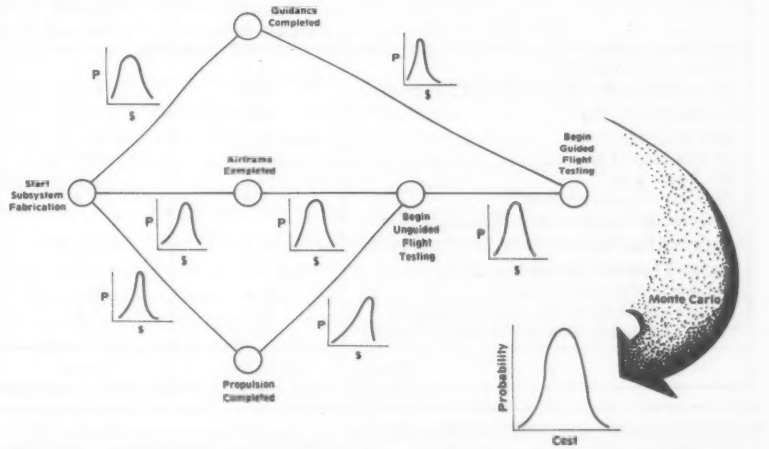
FIGURE 4
TRACE Probabilistic Event Analysis

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
		Primary Event A				Secondary Event B					
Program Element	Uncertain Event A	Prob. of occurrence	Cost Impact	Expected Value	Secondary Event B	P(B/A)	P(B)	Cost Impact	Expected Value	Total Expected Value	FY of Impact
Armor	Penetration test failure	.40	$3.0M	$1.2M	Suspension redesign req'd	.75	.30	$2.0M	$0.6M	$ 1.8M	82
Suspension	Additional weight growth	.60	1.0	0.6	—	—	—	—	—	0.6	82
Tracks	Failure to achieve MTBF	.75	2.0	1.5	Add'l delay in integration	1.0	.75	4.0	3.0	4.5	82
Power Train	Extension of testing	.40	1.0	0.4	—	—	—	—	—	0.4	82
Engine	Excessive fuel consumption	.60	3.0	1.8	—	—	—	—	—	1.8	82
Integration	Delay in start of testing	.90	5.0	4.5	Field testing delayed	1.0	.90	6.0	5.4	9.9	83
									TRACE Deferrals	$ 9.1M	FY82
										$ 9.9M	FY83
										$19.0M	Total

conjunction with the Monte Carlo simulation technique. The networks are schedule-oriented and can either include only planned, deterministic activities (Type I networks) or both planned and conditional decision activities (Type II networks).[11] Schedule and cost uncertainties, in the form of probability distributions, are estimated for each activity in the network computer model. The model is then run a sufficient number of times, in a Monte Carlo computer simulation, to generate probability distributions of estimated schedule and cost for the total program.

Although this method provides a highly flexible and responsive management tool once it is in place, it initially requires more time and highly skilled analysts to develop the program network model. It also requires access to a computer with a suitable network-evaluation software. At least one type of evaluation software, the risk information system and network evaluation technique (RISNET), is available in-house at the major subordinate commands within DARCOM.[12] Only one-fifth of those surveyed used this method, and half of those who did had the work done under contract by private consultants.

FIGURE 5
TRACE Probabilistic Network Modeling Technique



11. Type I and II networks are described in the Army briefing brochure on "The Trace Concept," reference (4) above. The Program Evaluation and Review Technique (PERT) uses Type I networks, whereas RISNET uses Type II networks.

12. "Total Risk Assessing Cost Estimate (TRACE)," p. 31.

Use of TRACE on Army Programs[13]

Army Regulation (AR) 1000-1, "Basic Policies for Systems Acquisition," states that major programs will use the TRACE concept in developing cost estimates.[14] Over the past 5 years (FY 78–82) roughly 20 programs have designated about $240 million in TRACE deferral funds. Through FY 1981, 99 percent of the deferral funds have been released to the program offices.[15] For example, in FY 1981 the advanced attack helicopter (AAH) program used TRACE deferral funds to fabricate equipment and instrumentation for another helicopter following an accident in the test program.

Very few, if any, of the programs underran their TRACE estimates. Less than 1 percent of the total deferral funds have been reprogrammed to other programs. The reason for this is that the TRACE statistical techniques only account for the "known unknowns"; they cannot anticipate the "unknown unknowns" that inevitably occur.

FIGURE 6
FY 1983 TRACE Programs

Program	Total FY 1983 RDT&E Amount	TRACE Deferral
COBRA TOW Missile	12.2	1.0
Army Helicopter Improvement Program	75.8	11.1
PATRIOT Missile	27.5	5.8
HELLFIRE Missile	19.3	12.0
PERSHING II Missile	111.3	29.3
M-1 Tank Gun	31.6	5.6
Tactical Communications	7.9	1.8
Modular Integrated Communication and Navigation System (MICNS) Data Link	14.8	3.5
Position Location Reporting System	9.4	.5
Remotely Piloted Vehicles	73.2	14.4
NAVSTAR Satellite Ground Equipment	11.9	1.0
Tactical Satellite Communications System	17.5	1.1
Total	$412.4M	$87.1M

13. For further information of the Army's use of TRACE contact Patricia Stone, DSCRDA/DAMA-PPR, (202) 697-4988 or Autovon 227-4988.

14. U.S. Army Regulation, "Basic Policies for Systems Acquisition," AR 1000-1, 1 May 1981, paragraphs 2-15.e, and 2-16.d.

15. Lieutenant Colonel James P. McGinnis, USA, and Captain Alan I. Kirschbaum, USAF, "TRACE Risk Assessment and Program Execution," unpublished student research paper, Defense Systems Management College, 7 December 1981.

The FY 1983 budget request contains $87.1 million in TRACE deferral funds for 12 programs within the Army's RDT&E budget. As shown in Figure 6, the TRACE deferral amounts range from over 60 percent (HELLFIRE) to under 6 percent (position location reporting system) of the total program cost.

Budgeting for Risk on Navy Programs[16]

Having looked at how the Army is using the TRACE concept, let us now turn our attention to the Navy. The stated policies of the Naval Material Command (NAVMAT) direct program managers to include risk assessment and the means for dealing with that risk as part of their acquisition strategies. This includes "a financial strategy which describes realistic funding necessary to achieve the acquisition objective."[17]

To comply with the direction included in Action 11 of the DOD acquisition improvement program, an *ad hoc* NAVMAT group met to consider the Army's TRACE concept. The result was that the Navy decided to test the TRACE concept on a selected group of Acquisition Category (ACAT) I and II programs in the Naval Air Systems Command (NAVAIR).[18]

The program managers on seven candidate programs were asked to develop TRACE estimates for their programs. The estimates were incorporated into the FY 1984 program objective memorandum (POM) submitted to the Office of the Chief of Naval Operations (OPNAV) by NAVAIR. The seven candidates included programs from three general categories: recently initiated programs (pre-Milestone II), programs just entering full-scale development (Milestone II), and ongoing major programs (post-Milestone II). Each program manager was free to select the risk quantification method most appropriate to his program. The methods chosen covered the spectrum of techniques previously described.

The Navy TRACE management concept differs from that used by the Army. The Navy plans to withhold the TRACE deferral funds at the system command level—NAVAIR headquarters. Release of deferral funds will require approval of the commander of NAVAIR. Thus, management of the Navy TRACE funds will occur two levels lower in the Navy management hierarchy than in the Army.

Based on the outcome of the NAVAIR test of the TRACE concept, NAVMAT will decide if the management concept and budgeting methods can be applied to the other system commands.

Budgeting for Risk on Air Force Programs

Like the Navy, the Air Force also evaluated the Army's TRACE concept. In its

16. For further information on the Navy's use of TRACE contact Robert Johnson, NAVAIRSYSCOM/AIR-12, (202) 692-7988 or Autovon 222-7988.

17. Naval Material Command Instruction 5000.29, "Acquisition Strategy," October 1981.

18. ACAT I programs are those for which the Secretary of Defense is the decision authority. ACAT II programs have either the Secretary of the Navy or the Chief of Naval Operations as the decision authority.

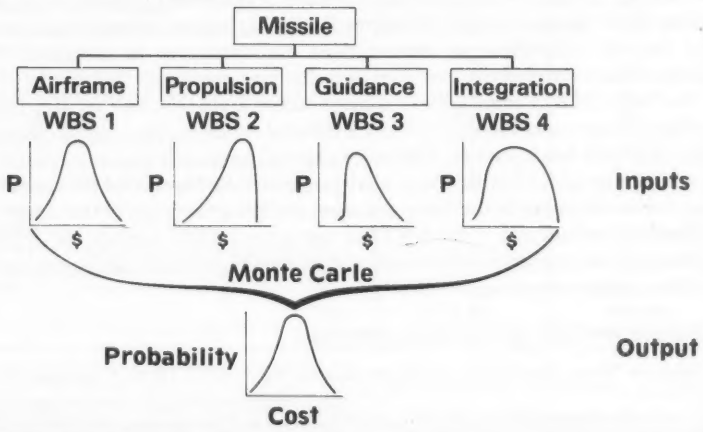
reply to the Office of the Secretary of Defense (OSD), the Air Force stated that it was using and would continue to use risk assessment techniques that are essentially equivalent to TRACE.[19] One of these techniques, the Air Force Systems Command (AFSC) RISK Model, will be discussed below.

The Air Force has a different philosophy than the Army and Navy on how the funds budgeted for risk should be administered. Whereas in the Army and Navy the TRACE deferral funds are withheld at higher headquarters levels and the program manager must justify their release, the Air Force normally distributes all funds to the program manager. The Air Force does not plan to adopt the deferral concept, because it believes it diminishes the management authority of the program manager, encourages him to budget additional undisclosed reserves, and does not provide higher headquarters with more funding flexibility than it already has. The Air Force believes its approach is in keeping with the management principle of controlled decentralization espoused in the DOD acquisition improvement program.

The AFSC RISK Model

One of the techniques used by the Air Force to evaluate and quantify risk, for

FIGURE 7
AFSC RISK Model



19. James E. Williams, Jr., memorandum for the Under Secretary of Defense for Research and Engineering, subject: "Improving the Acquisition Process," 24 September 1981.

both RDT&E and early production programs, is the RISK Model developed by AFSC's Armament Division at Eglin AFB, Fla.[20] The model is available on the COPPER IMPACT computer time-sharing network. The RISK model is like the Army's risk-factor method in that it is based on the program WBS. However, as shown in Figure 7, the RISK model requires that a cost distribution, rather than a single risk factor, be defined for each WBS element. The inputs that must be made to the model to define the cost distribution include: the point estimate of the cost (equivalent to the TRACE BCE); the highest and lowest costs possible, and the variation of possible costs around the point estimate within this high-low range. In the model, only four discrete variance approximations, which represent the shape of the distribution, are used—"low," "medium low," "medium high," and "high." A lower variance implies a more peaked distribution. The cost range and variance inputs should be based on the estimator's confidence in: the cost-estimating techniques used and their applicability to the program; the firmness of the program schedule; the degree of technology advance required; and the stability of the system configuration. Once these inputs have been made, the model uses a Monte Carlo simulation technique to sum sample cost observations from each WBS element cost distribution into a total program cost distribution.[21]

The computer prints out the total program cost distribution in both tabular and graphic forms. The median value of the cost distribution is considered to be the "best estimate of total program cost," since there is a 50 percent chance that the program can be accomplished within that amount. The difference between the amount the program manager decides to request and the median value represents his management reserve for risk. Unlike the old rule of thumb of adding "X" percent, the RISK model shows the program manager what each dollar increment adds to his program in terms of additional probability of success.

Extension of the TRACE Concept to Early Production

As mentioned earlier, the Army currently uses the TRACE only on RDT&E programs. However, there is a great deal of risk involved in making the transition from development to early production.[22] Because the nature of the risks involved is different, it was not clear if existing TRACE methods could be directly applied to the early production phase.

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20. Headquarters Air Force Systems Command/ACC letter, subject: "Risk Model Documentation," 1 June 1981. For further information on this model contact A. Fatkin, AFSC/ACCE, (301) 981-4306 or Autovon 858-4306.

21. The RISK model assumes that the cost changes in each WBS element are interdependent as opposed to independent. Thus, a single random number is used to generate observations from all of the WBS element cost distributions as opposed to using a different random number for each WBS element.

22. John D. Nichols, Chairman, *Report of the U.S. Army Ad Hoc Cost Discipline Advisory Committee*, 16 December 1981.

For this reason, in June 1981, as part of the acquisition improvement program, the Army directed the Army Procurement Research Office (APRO) at Fort Lee, Va., to study the use of a TRACE-like concept for programs entering production. The APRO report submitted to DARCOM headquarters identified the problems encountered in transitioning into production and grouped them into generalized risk categories. These categories are designed to provide a framework for applying conventional cost-estimating techniques to the problem of budgeting for risk

Based on the APRO report, DARCOM refined the risk categories and developed a budgeting methodology and management concept that is now being staffed through DCSRDA. As it now stands, the concept will be applied on a limited basis to selected programs in the Army's FY 1984 POM submission. The management concept used will be similar to that used with RDT&E TRACE—the risk dollars will be identified within the program line and withheld at Army headquarters level until justified and approved for release to the program office.

This completes the discussion of where the DOD and the services are in terms of their responses to Action 11. With that background, the next section outlines the advantages and disadvantages of budgeting for risk.

Advantage and Disadvantages of Budgeting for Risk

There are many advantages that can accrue from budgeting for risk. First, and most important, it ensures an open discussion and recognition of the risks involved in the program. That discussion, in turn, facilitates adequate planning to deal with the risks identified. Second, if program funding is based on more realistic cost estimates that account for risk, those programs will be more stable in the long run. Funds will be available quickly to resolve problems as they arise without the need to stretch schedules, reduce program scope, or request reprogramming.

On the other hand, there are both real and perceived disadvantages. Like many of the other actions within the Acquisition Improvement Program, Action 11 required "up-front" funds. That means that fewer programs can be fitted within the total obligation authority (TOA) available. This is probably acceptable if those fewer programs are also more stable programs less subject to stretchouts. Furthermore, if the risk management reserve funds are openly identified they may prove to be a self-fulfulling prophecy. The funds deferral and release justification procedures, if properly applied, can prevent this from occurring. Finally, unless system discipline is enforced, the risk funds may become an attractive target in budget cutting and redistribution exercises.

Summary

This article has described management concepts used by each of the services in budgeting for risk, as well as several techniques for quantifying risk in dollars

terms. The point is that there is no single right way of doing it. What is important for program managers and their staffs, is that they have an approach that forces systematic thinking about program uncertainty and risk before it occurs. The intuitive "X" percent rule-of-thumb approach to budgeting for risk reveals nothing that could improve program management. It would be much more profitable to use one of the more rigorous methods to estimate the level of program risk and the funds needed to cope with that risk. Whether the risk funds are obtained through conventional or "creative" budgeting is immaterial. The real benefit comes from having thought about and planned for unpredictable events. The end result is that you will have Mr. Murphy and his bag of unpleasant surprises firmly under control. ||

The Acquisition Process: A Brief Historical Perspective

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David D. Acker

Before delving into the new DOD Acquisition Improvement Program and its implementing actions, it may enhance your understanding to know the evolution of the basic defense systems acquisition process, which can be traced back to the 1950s.[1] This brief perspective will cover only the period beginning with the Laird-Packard era at DOD, and ending with the initiation of the DOD Acquisition Improvement Program at the start of the Weinberger-Carlucci era in 1981.

At the close of the 1960s, Congress was displaying a preoccupation with the economy, the environment, and energy. At the same time, it was showing an increasing sentiment toward the funding of social programs, and a disenchantment with the conflict in Vietnam and the escalating costs of the defense systems acquisition programs. Thus it was that, as U.S. involvement in Southeast Asia came to an end, the defense effort became a primary target for budget cuts. To cope with this situation, Defense Secretary Melvin R. Laird and his deputy, David Packard, initiated a number of actions aimed at improving the management of the defense systems acquisition process and gaining control of program costs.

Program Management Reviews

In May 1969, Deputy Secretary Packard established the Defense Systems Acquisition Review Council (DSARC) within the Office of the Secretary of Defense (OSD) to advise the Secretary of Defense (SECDEF) of (1) the status and readiness of each major defense system to proceed from one program phase to the next phase in its life cycle, and (2) actions to be taken on those issues that the DSARC chairman (the Director of Defense Research and Engineering [DDR&E]) considered to be significant.[2]

In addition to the DSARC actions, Mr. Packard requested that the DDR&E conduct a management review at least once on each major acquisition program.

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1. David D. Acker, "The Maturing of the DOD Acquisition Process," *Defense Systems Management Review*, Summer 1980, Volume 3, Number 3.

2. David Packard, memorandum to the Secretaries of the military departments, Director of Defense Research and Engineering, Assistant Secretaries of Defense, and others, subject: "Establishment of a Defense Systems Acquisition Review Council," 30 May 1969.

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Such reviews proved to be helpful in determining those OSD actions that should be taken to improve the management of the defense systems acquisition process.

Origin of DOD Directive 5000.1

In May 1970, the Deputy Secretary issued a memorandum citing other ways to improve the process of acquiring major defense systems.[3] The essential features of this memorandum served as the basis for the July 1971 DOD Directive 5000.1, "Acquisition of Major Defense Systems," the first of a number of directives and associated instructions in the "5000 series."[4] The memorandum (and directive) stated Mr. Packard's belief that "successful development, production, and deployment of major defense systems are primarily dependent upon competent people, rational priorities, and clearly defined responsibilities." It called for decentralization of responsibility and authority for the acquisition of major defense systems to the greatest extent possible, consistent with the urgency and importance of a particular defense system being acquired.

Department of Defense Directive 5000.1 ordered that program managers be given adequate authority to make major decisions, rewards for good work, and more recognition toward career advancement. The OSD assumed responsibility for establishing acquisition policy and assuring the major programs were being pursued in response to specific needs. The DOD components (military departments and defense agencies) were given responsibility for identifying needs and defining, developing, and producing systems to satisfy those needs.

Actions to Support Secretary of Defense Decision-Making

In accordance with DOD Directive 5000.1, monitoring the progress of each major acquisition program was a joint responsibility of OSD and the DOD components. Accordingly, OSD disengaged from the detailed direction of the acquisition process and assumed the role of decision-maker only at milestones associated with major systems. The monitoring process required that a "contract" be established between OSD and the procuring DOD components. At the outset the development concept paper (DCP)—later to be called the decision coordinating paper—served as the contract. The DCP—administered by the DSARC chairman—provided the basic documentation for use by the DSARC in arriving at the recommendations for the SECDEF. This document was approximately 20 to 100 pages in length. It included a description of the program; a revalidation of the mission need; a summary of the acquisition strategy; system and program alternatives; technical, cost, and schedule goals; the thresholds which, if exceeded,

3. David Packard, memorandum to the Secretaries of the military departments, Director of Defense Research and Engineering, Assistant Secretaries of Defense, and others, subject: "Policy Guidance on Major Weapons Systems Acquisition," 28 May 1970.

4. U.S. Department of Defense Directive 5000.1, "Acquisition of Major Defense Systems," 13 July 1971.

would be the basis for a review of the entire program; the number of systems to be acquired, supported, and maintained; the anticipated life-cycle cost; and other issues affecting DSARC decisions.

The DSARC was formally recognized as the group that would support SECDEF decision-making at each program milestone. When the DSARC determined that the program was ready to advance to the next phase, the chairman made such a recommendation to the SECDEF, who had the decision authority. The SECDEF decisions at Milestones I, II, and III were reflected in a revision to the DCP and normally incorporated in the five-year defense program (FYDP) documentation at the next program objectives memorandum (POM) submission. The POM is a document prepared annually by each military department and defense agency to describe how that department or agency proposes to allocate and prioritize the limited resources it may receive among the competing needs to maximize combat capability. The POM includes an assessment of the risk associated with current and proposed forces and support programs.

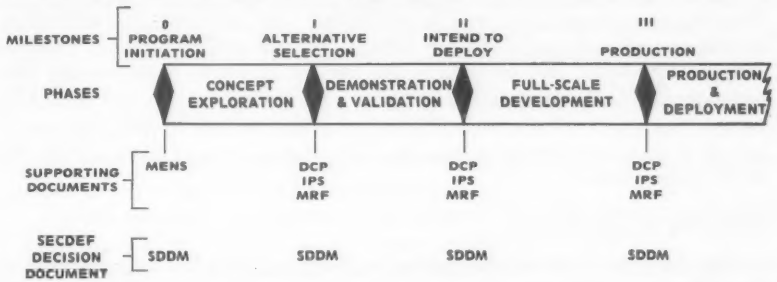
By the close of the 1970s, the one- to three-page SECDEF decision memorandum (SDDM), rather than the DCP, was serving as the "contract" between OSD and the procuring DOD component. The SDDM recorded the SECDEF decisions and directions following receipt of DSARC recommendations; breaches of a program threshold; planning, programming, and budgeting system (PPBS) and/or congressional actions that affect program execution.

The integrated program summary (IPS)—a 60-page document developed in the early 1980s—provided information for a management overview of the entire program. It included some of the information that had formerly been presented in the DCP; therefore, the number of pages was reduced to ten. The IPS summarized the implementation plan for the complete acquisition processing of a particular system, with emphasis on the next program phase, to allow informed analysis by interested OSD staff members and the DSARC. It included such topics as the program history, program alternatives, threat assessment, cost-effectiveness analyses, system vulnerability, organizational and operational concepts, acquisition strategy, technology assessment, contracting, manufacturing, configuration and data management, test and evaluation, logistics, and the elements of cost. The mandatory annexes included a cost track summary, a funding profile, a summary of system acquisition costs, manpower requirements, and logistics data.

A milestone reference file was established at each milestone. This central file of existing program documentation referenced in the DCP and IPS was available for use by DOD personnel who needed information related to a program milestone.

The program phases, milestones, and coordinating documents used prior to implementing the DOD Acquisition Improvement Program are shown in Figure 1.

FIGURE 1
Major Systems Acquisition Process Prior to Implementation of DOD Acquisition Improvement Program



Need for Cost Goals and Realistic Cost Estimates

In the late 1960s, the need to establish design-to-cost goals on all major defense systems programs was recognized at the OSD level. The rising costs of acquiring, operating, and supporting defense systems and equipment created the need. Dr. John S. Foster, Jr., then Director of Defense Research and Engineering, said in 1972 that unless the government and defense industry changed the way they were doing business, ". . . the things [industry] sells and [the government] wants to buy will grow too expensive to provide an adequate national defense under limited funding."

In response to the need, the Joint Logistics Commanders issued in October 1973, as information and guidance to their commands, a *Joint Design-to-Cost Guide*.[5] Then, in May 1975, DOD Directive 5000.28, "Design-to-Cost," was issued by the Deputy Secretary of Defense, William P. Clements, Jr., formalizing the direction of design-to-cost throughout the Department of Defense.[6] The objectives of design-to-cost, as set forth in the directive, were as follows:

—To establish cost as a parameter equal in importance with technical requirements and schedules throughout the design, development, production, and operation of defense systems, subsystems, and components; and

—To identify and establish cost elements as management goals for program managers and contractors to achieve the best balance between life-cycle cost, acceptable performance, and schedule.

Going back to 1969, the Laird/Packard team determined the need for independent cost analyses by the services and review by a group at the OSD level.

5. Department of the Army, Navy, and Air Force pamphlet, *Joint Design-to-Cost Guide*, DARCOM P700-6, NAVMAT P5242, AFLCP/AFSCP 800.19, 3 October 1973.

6. U.S. Department of Defense Directive 5000.28, "Design-to-Cost," 23 May 1975.

Unrealistic cost estimates on past defense systems programs were a matter of record and poor estimates were considered a significant factor in what was perceived to be cost growth on major programs. A review group, to be known as the Cost Analysis Improvement Group (CAIG), was established in January 1972.[7] The CAIG was chartered to provide the DSARC with an independent evaluation of the cost of each major defense system program and to establish uniform criteria, standards, and procedures for use by all DOD units making cost estimates. DOD Directive 5000.4 provided a permanent charter, and the CAIG became "an advisory body to the DSARC on matters related to [program] cost," as well as the focal point for cost-analysis activities involving OSD staffs and the DOD components.[8]

Maturing of the Process

The maturing of the defense systems acquisition process has been described in the following manner:

> . . . the late 1950s and 1960s were characterized by centralized control at the OSD level, by overreaction to the management problems, by procedures and regulations that were too detailed, by multitudinous paper studies to determine risks (rather than by hardware testing), by management theories that were too often in conflict with real-life practices, and by growing industry frustrations.
>
> But the situation wasn't all bad. The findings of the President's Blue Ribbon Defense Panel in 1970 allayed many misconceptions held during that period. For example, the panel report showed that defense industry was not making excessive profits, the contracting practices being used were not illegal, and conflict of interest did not exist between military personnel and defense contractors. . . .
>
> By the close of the 1970s, the length of the acquisition process—from initial system concept to initial operational capability—was averaging five more years than it did in the middle of the 1950s. Most of this increase was caused by the additional front-end actions and, to some extent, by an increase in the period from the completion of full-scale development to achievement of full operational capability. The average full-scale development time has remained essentially the same over the years.
>
> At the threshold of a new decade (the 1980s) DOD is faced with a series of problems that need solutions if the United States is to at least maintain its current force levels.[9]

7. Melvin R. Laird, memorandum to the Secretaries of the military departments, subject: "Cost Estimating for Major Defense Systems," 25 January 1972.

8. U.S. Department of Defense Directive 5000.4, OSD Cost Analysis Improvement Group, 13 June 1973.

9. Acker, p. 70.

New Federal Policy Implemented

In April 1976, the Director, Office of Management and Budget (OMB), and the first Administrator, Office of Federal Procurement Policy (OFPP), issued a new policy for the acquisition of major systems. The new policy, OMB Circular A-109, "Major Systems Acquisition," (patterned after DOD Directive 5000.1) defined a major system.[10] The OSD then designated a system as "major" if it met the criteria set forth in OMB Circular A-109, as well as the following criteria:

(1) Development risk, urgency of need, or other items of interest to the SECDEF;

(2) Joint acquisition of a system by the DOD and representatives of another nation or by two or more DOD components;

(3) The estimated requirement for the system's research, development, test, and evaluation (RDT&E), and procurement (production) funds;

(4) The estimated requirement for manpower to operate, maintain, and support the system in the field;

(5) Congressional interest.

A defense program was categorized as "major" if the estimated costs for RDT&E and procurement (production) on the program exceeded $100 million and/or $500 million, respectively, or the program was designated by the SECDEF to be of such importance and priority as to require special management attention.

Defense Science Board Report

One of the comments made by Dr. Richard D. DeLauer, Chairman of the Acquisition Cycle Task Force of the Defense Science Board, following the 1977 Summer Study, is worthy of note here:

> The progression of acquisition policy changes from Total Package Procurement through the DSARC process, fly-before-buy, full-scale prototyping, increased emphasis on operational test and evaluation, and up to the current OMB Circular A-109 policy, has evolved out of the perceived need to correct the deficiencies observed in specific programs by introducing additional management review and decision procedural checkpoints to assure that past mistakes would not be repeated. These procedural changes have become institutionalized and have been applied inflexibly to all

10. A major system is "that combination of elements that will function together to produce the capabilities required to fulfill a mission need. The elements may include, for example, hardware, equipment, software, construction, or other improvements on real property. Major system acquisition programs are those programs that (1) are directed at and critical to fulfilling an agency mission, (2) entail the allocation of relatively large resources, and (3) warrant special management attention. Additional criteria and relative dollar thresholds for the determination of agency programs to be considered major systems under the purview of this Circular, may be established at the discretion of the agency head."

> programs with the result that the acquisition process has steadily lengthened and the procurement of defense systems has become increasingly costly.
>
> Lack of realism in estimation of program costs, changes in specified performance requirements, inflation, and other such causes of "cost growth" have caused the aggregate cost of planned production programs to substantially exceed the allocated budgetary resources, resulting in the need to delay the completion of the production phase of programs in order to fit the total available defense budget in each fiscal year. The "bow wave" effect created by too many programs in full-scale development at any given time in relation to the available production funds results in an acquisition cycle for the typical defense system which is an excess of the optimum length of time and is more costly than planned or estimated.[11]

With Dr. DeLauer as the Under Secretary of Defense, Research and Engineering, as well as the Defense Acquisition Executive, this task force report has taken on added significance.

The Basic Acquisition Process

At this point let's examine the basic defense systems acquisition process as it existed at the beginning of the present administration. The acquisition process normally began following agreement between the SECDEF and the DOD component heads that a valid need for a defense system existed. The need was usually stated in terms of the operational task to be accomplished. Each component appointed its program managers. In the case of a joint-service program, the SECDEF designated the lead DOD component for that program and the responsibilities for intercomponent matters were set forth in a joint-services memorandum of agreement.

Phases of the Acquisition Process

The DOD components identified the need for new acquisition programs in the yearly submission of the POM. Each proposed new major acquisition program identified in the POM required a mission element need statement (MENS). The MENS—the document on which the initial milestone decision on a new major defense system program was based for the past several years—identified and defined a need based upon a projected threat, evaluated the ability of current or planned defense systems to cope with the projected threat, and stated how soon a defense system should be fielded to meet the threat, i.e., correct the deficiency.

Now, let's briefly consider the program phases:

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11. Report of the Acquisition Cycle Task Force, Defense Science Board Summer Study, 15 March 1978, p. 1.

Concept Exploration: The objective of the competitive concept exploration phase was to clearly identify and document the system need and alternative system concepts to satisfy the need. Early in the concept-exploration phase of a program, when alternatives were being considered, the requirement for standardization and interoperability of the defense system, as defined by the North Atlantic Treaty Organization (NATO), was taken into account.

Demonstration/Validation: The basic objective of the demonstration/validation phase was to verify the feasibility of the defense system concept. The major characteristics of the competing alternative system concepts were demonstrated, validated, and refined; program risks and uncertainties were assessed and treated; logistics issues, such as system readiness, reliability, maintainability, resupply time, and spares requirements were considered and resolved; and cost targets were established. One (or more) of the alternative defense system concepts was then approved for entry into the next phase. If the SECDEF decided the risk was small, the demonstration and validation phase was omitted and the program proceeded directly from concept exploration to full-scale development.

Full-Scale Development: The objectives of the full-scale development phase were to design and develop the defense system (or systems), along with the principal equipment required for its support. Long-lead items were procured. A limited number of systems for operational test and evaluation were produced. The established cost, performance, and schedule thresholds were reviewed to ensure they were consistent with the risks involved.

Production and Deployment: The objectives of the production phase were to produce the defense systems and their support equipment. Planning for deployment, including the assignment and training of personnel and preparation for logistics support, took place. During deployment, completely integrated defense systems were delivered to the using and supporting commands.

Principal Program Decisions

Before the start of each phase in the defense system acquisition process, there was an opportunity to reassess the need for the system, and the ability of that system to counter a known or perceived threat. Typically, these assessments occurred at four key points, generally referred to as "milestones," in the systems acquisition process. Following the reassessment and review of the defense system by senior DOD management, a decision was made to move ahead as planned, to modify the plan, or to discontinue the program.

Although special reviews were held at any time when matters jeopardizing the success of a program were perceived, major decisions were required at the following points in the acquisition process:

Milestone 0—When a DOD component head submitted a MENS that identified and defined a specific deficiency (or opportunity) within a mission area, and SECDEF approval to consider system concepts that would overcome that deficiency was required.

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Milestone I—When the concerned DOD component(s) completed concept exploration and the risks were judged such that the effort was considered to be ready for demonstration and validation.

Milestone II—When (1) the program characteristics had been demonstrated, validated, and refined; (2) the program risks and cost had been assessed and minimized; and (3) one (or more) defense system(s) concept was ready for development, limited production, and operational test and evaluation.

Milestone III—When the testing and evaluation of the initial production units demonstrated that an effective, economical, and supportable defense system(s) was ready for full-scale production and delivery to the using and supporting commands.

The DOD Acquisition Improvement Program

The articles that follow will describe the changes in the program management environment brought about by the DOD Acquisition Improvement Program. You will quickly note that many of the actions covered in these articles are not, for the most part, new ideas. For example, controlled decentralization and increased program manager authority and responsibility are two ideas most of us have heard about in the past. The key to the DOD Acquisition Improvement Program, then, is not that it has created any radically new ideas; rather, it has gathered together the best ideas generated over many years of study and coupled them with a high-level management commitment to see that they are implemented. You are encouraged to keep this thought in mind as you select specific articles for reading from this edition of *Concepts*. ||

83 The Acquisition Process: New Opportunities for Innovative Management

David D. Acker
George R. McAleer, Jr.

Deputy Secretary of Defense Frank C. Carlucci, perceiving a need for economy and efficiency in defense systems acquisition, took action in the spring of 1981 by chartering five working groups composed of representatives from the Office of the Secretary of Defense (OSD) and the services. These working groups reviewed the current acquisition process and, by means of a combined report, recommended changes to the process. This report, which included inputs from industry, was submitted to the Deputy Secretary of Defense (DEPSECDEF) on March 31, 1981.

After reviewing the report and discussing its contents with the Secretary of Defense (SECDEF), the Joint Chiefs of Staff, the service secretaries, and others, Mr. Carlucci wrote, ". . . the Secretary and I have decided to make major changes both in acquisition policy and the acquisition process itself." Accordingly, on April 30, 1981, Mr. Carlucci initiated a series of 31 innovative actions.[1] On July 27, 1981, he added another action, Competition.[2] Taken together, these innovative actions have become known as the Department of Defense (DOD) Acquisition Improvement Program.

This article will describe the changes to the Defense Resources Board (DRB), the Defense Systems Acquisition Review Council (DSARC), and the basic acquisition process resulting from implementation of the DOD Acquisition Im-

1. Frank C. Carlucci, memorandum to the Secretaries of the military departments, Chairman of the Joint Chiefs of Staff, Under Secretaries of Defense, and others, subject: "Improving the Acquisition Process," April 30, 1981.

2. Frank C. Carlucci, memorandum to the Secretaries of the military departments, Chairman of the Joint Chiefs of Staff, Under Secretaries of Defense, and others, subject: "Increasing Competition in the Acquisition Process," July 27, 1981.

David D. Acker is a Professor of Management in the Research Directorate at the Defense Systems Management College. Prior to joining DSMC, he was assigned for 3 years to the Office of the Director, Defense Research and Engineering, where one of his responsibilities was the development, coordination, and communication of policy associated with major defense systems acquisition. He was directly involved in the writing of the initial draft of DOD Directive 5000.1 and in the preparation of the first drafts of DOD Directives 5000.2, 5000.3, and 5000.19. Mr. Acker spent 23 years in industry in design engineering, project engineering, and program management associated with Air Force, Navy, and Army contracts. He has taught engineering and management courses at Rutgers University, VPI, and UCLA, and is the author of numerous articles on management, design, and communications. Mr. Acker holds B.S. and M.S. degrees in mechanical engineering from Rutgers University.

George R. McAleer, Jr., is Head of the Acquisition Management Laboratory Department at the Defense Systems Management College. He has been a program manager in both military and industrial environments. Mr. McAleer spent several years as an Air Force program manager with the Electronic Systems Division. A significant part of his industrial program management experience has been in the defense sector with Fairchild Industries, Carborundum Company, and Grove Manufacturing Company, a division of Walter Kidde. Mr. McAleer has been Associate Professor at the Frostburg State College Center for Management Development, a graduate business school. He holds a B.S. degree in engineering from the U.S. Naval Academy and an M.S. degree in management from Rensselaer Polytechnic Institute.

provement Program. It will also outline several of the challenges still facing the acquisition management community. During the discussion, the following actions associated with the Acquisition Improvement Program will be dealt with directly:

Action 17 Decrease DSARC Briefing and Data Requirements
Action 24 Reduce DSARC Milestones
Action 25 Submit Mission Element Need Statement (MENS) with Service Program Objectives Memorandum (POM)
Action 26 Revise DSARC Membership
Action 27 Retain Under Secretary of Defense for Research and Engineering (USDRE) as Defense Acquisition Executive
Action 28 Raise Dollar Thresholds for DSARC Review
Action 29 Integrate DSARC and Planning, Programming, and Budgeting System (PPBS)

First, let's consider the changes to the Defense Resources Board (DRB), an advisory board formed in April 1979 and chaired by the DEPSECDEF.[3]

Defense Resources Board

The DRB was chartered to assure that major defense systems programs were closely aligned to the PPBS. In addition, the DRB was charged with the following:

—Directing and supervising OSD review of service POMs and budget submissions.

—Examining and resolving major service issues without SECDEF involvement, if possible.

—Presenting recommendations to the SECDEF for his action when deemed desirable.

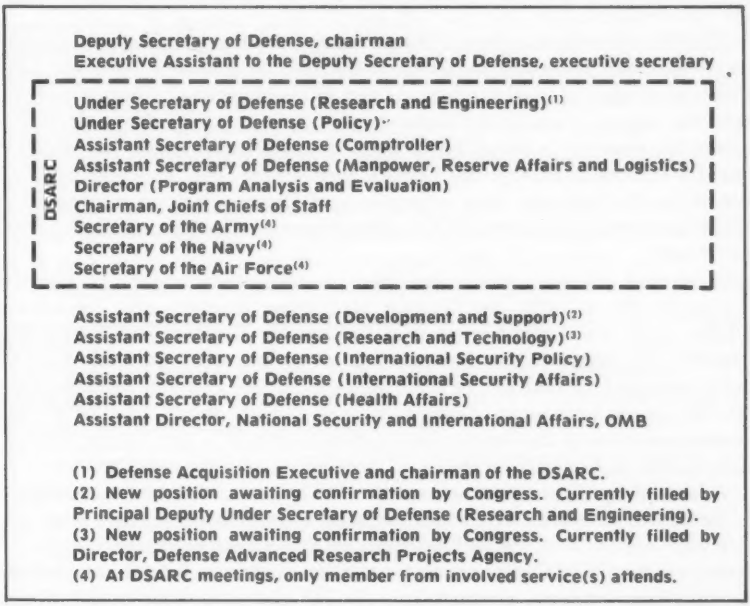
On March 27, 1981, the chairman of the DRB, Mr. Carlucci, directed that the role and membership of the DRB be expanded.[4] Figure 1 displays the expanded membership of the DRB and points out the relationship of its membership to the DSARC membership. The principal changes to the membership are the addition of the Chairman of the Joint Chiefs of Staff and the service secretaries, as well as the Associate Director from the Office of Management and Budget.

According to Mr. Carlucci, the primary role of the expanded DRB is to help the SECDEF manage the entire revised planning, programming, and budgeting system. He plans to hold regular monthly DRB meetings to (1) review proposed

3. Dr. Harold Brown, memorandum to the Secretaries of the military departments, Chairman of the Joint Chiefs of Staff, Under Secretaries of Defense, and others, subject: "Establishment of Defense Resources Board," April 7, 1979.

4. Frank C. Carlucci, memorandum to the Secretaries of the military departments, Chairman of the Joint Chiefs of Staff, Under Secretaries of Defense, and others, subject: "Management of the DOD Planning, Programming and Budgeting System," March 27, 1981.

FIGURE 1
The Defense Resources Board


Deputy Secretary of Defense, chairman
Executive Assistant to the Deputy Secretary of Defense, executive secretary
DSARC
Under Secretary of Defense (Research and Engineering)(1)
Under Secretary of Defense (Policy)
Assistant Secretary of Defense (Comptroller)
Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics)
Director (Program Analysis and Evaluation)
Chairman, Joint Chiefs of Staff
Secretary of the Army(4)
Secretary of the Navy(4)
Secretary of the Air Force(4)
Assistant Secretary of Defense (Development and Support)(2)
Assistant Secretary of Defense (Research and Technology)(3)
Assistant Secretary of Defense (International Security Policy)
Assistant Secretary of Defense (International Security Affairs)
Assistant Secretary of Defense (Health Affairs)
Assistant Director, National Security and International Affairs, OMB
(1) Defense Acquisition Executive and chairman of the DSARC.
(2) New position awaiting confirmation by Congress. Currently filled by Principal Deputy Under Secretary of Defense (Research and Engineering).
(3) New position awaiting confirmation by Congress. Currently filled by Director, Defense Advanced Research Projects Agency.
(4) At DSARC meetings, only member from involved service(s) attends.

(Note: The permanent members of the Defense Acquisition Review Council are also members of the DRB.)

planning guidance, (2) manage the program and budget review process, (3) advise the SECDEF on policy, planning, program and budget issues, and proposed decisions, (4) perform program evaluations and reviews of high priority programs on a regular basis, and (5) assure that major acquisition systems are more closely aligned to the PPBS. The DRB chairman said that he expects DRB members to be more than advocates of their particular areas of responsibility; they must take a broader and deeper DOD view and help the SECDEF and DEPSECDEF manage DOD better.

A limited number of major issues will be presented to the DRB. Lesser issues will be decided outside the DRB by consensus between the services and appropriate OSD staff. Decisions will be recorded on appropriate decision documents. In all cases, the consensus will have to reflect DOD and administration policy. Where consensus cannot be reached, the issue will be referred to the DRB.

Second, let's consider the changes to the Defense Systems Acquisition Review Council (DSARC), chaired by the Defense Acquisition Executive (DAE).

Defense Systems Acquisition Review Council

The DSARC is the top-level DOD corporate body for defense system acquisition. It provides advice and comments to the SECDEF following Milestone I and II reviews of defense system programs and following special program reviews. Upon the request of any one of its members, it can meet to consider a significant issue at any point in the acquisition process for any defense system. The SECDEF, upon the recommendation of the DSARC through the DAE, may accept the advice of the DSARC and issue a Secretary of Defense decision memorandum (SDDM), or he may issue an SDDM without benefit of a recommendation from the DSARC.

As a result of the issuance of the Office of Management and Budget Circular Number A-109 in 1976, the Director of Defense Research and Engineering (DDRE), now the Under Secretary of Defense for Research and Engineering (USDRE), was appointed the Defense Acquisition Executive.[5] As both the DAE and chairman of the DSARC, he is the principal advisor and staff assistant to the SECDEF for the acquisition of defense systems and equipment. The USDRE will continue to serve as the Defense Acquisition Executive in accordance with implementation of Action 27 of the DOD Acquisition Improvement Program.

A list of the permanent members of the DSARC is shown in the inset in Figure 1. The service secretaries were added to the list of permanent members in accordance with Action 26 of the DOD Acquisition Improvement Program. Principal advisors to the DSARC were appointed to make recommendations in such areas as acquisition strategy, producibility, NATO affairs, defense policy, threat assessment, test and evaluation, cost, and logistics support. These advisors attend a DSARC meeting only at the invitation of the DAE.

Implementation of Action 29 of the DOD Acquisition Improvement Program requires that the services be able to assure the DSARC that sufficient resources exist in the five-year defense program (FYDP) to execute the program as planned. The DSARC reviews individual programs at significant milestones to determine readiness to proceed to the next phase. Detailed review of the financing is accomplished by the DRB, which includes the DSARC members. The DRB considers all programs within a resource allocation framework; therefore, the lack of an explicit resource commitment during DSARC processing will not cause the problem (disconnect) it did in the past. Figure 2 identifies programs on which actions taken during PPBS processing in the past resulted in a 15 percent or greater change in the number of systems previously authorized for manufacture.

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5. Office of Management and Budget Circular Number A-109, "Major Systems Acquisitions," April 5, 1976.

The New Approach

The DOD Acquisition Improvement Program being orchestrated by Mr. Carlucci places emphasis on improving long-range planning, shortening the acquisition time, budgeting more realistically, reducing acquisition costs, and enhancing program stability. To accomplish these objectives, both the OSD and the DOD components are to delegate more responsibility and authority to the managers at lower echelons. Specifically, the SECDEF expects program managers to be given sufficient responsibility and authority, along with adequate resources, to efficiently execute their assigned tasks. Program managers will be held accountable for the success of their programs. The DOD components are expected to examine evolutionary alternatives to satisfy identified mission needs—alternatives that involve lower risks. Alternatives that require solutions at the frontier of technology are to be minimized or even avoided, if possible.

Implementation of Action 28 (identified above) resulted in a new definition

FIGURE 2

Programs on Which Actions Taken During PPBS Processing Resulted in a 15 Percent or Greater Change in Production Quantities Previously Authorized for Manufacture

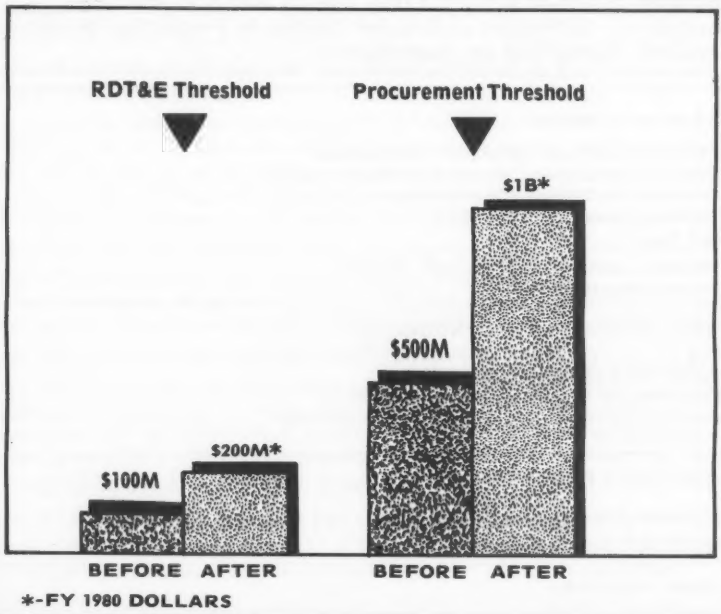
ARMY PROGRAMS
CH-47 Medium-Lift Helicopter Modification **Copperhead Cannon-Launched Guided Projectile** **Division Air Defense (DIVAD) Gun** **Fighting Vehicle System (FVS)** **M-1 Tank** **Multiple Launch Rocket System (MLRS)** **Roland Missile System**
NAVY/MARINE CORPS PROGRAMS
Advanced Radar Warning System **Intermediate Water Depth (IWD) Mine** **Harrier V/STOL Light Attack Aircraft (AV-8B)** **F-18 Aircraft**
AIR FORCE PROGRAMS
Airborne Command Post (E-4) **NAVSTAR Global Positioning System**
JOINT PROGRAM
Joint Tactical Communications Program (TRI-TAC) Switches

for a "major defense system." According to the new definition set forth in the recent revision of DOD Directive 5000.1, DOD will continue to be guided by the criteria in OMB Circular Number A-109.[6] However, the DOD interpretation of Item (3) of the criteria has been changed to state:

> The decision to designate any system as major may, after consultation with the appropriate DOD Component, be based upon . . . the estimated requirement for the system's research, development, test and evaluation, procurement (production), and operation and support resources. A Justification for Major System New Start (JMSNS) document [replaces MENS] is required for all acquisitions for which the DOD Component estimates costs to exceed $200 million (FY 80 dollars) in RDT&E funds and/or $1 billion (FY 80 dollars) in procurement (production) funds. [See Figure 3.]

FIGURE 3

Major System Cost Thresholds Before and After Implementation of DOD Acquisition Improvement Program



6. U.S. Department of Defense Directive 5000.1, "Major Systems Acquisitions," March 29, 1982.

As a result of the implementation of Action 28, 10 programs were removed from the list of major programs; i.e., the number of major programs dropped from 52 to 42. Figure 4 identifies the programs no longer considered "major" as a result of raising the dollar threshold specified in the definition of a major defense system. This action decentralizes the control of these programs. It may shorten the acquisition time for the programs removed from the list.

Other programs initiated prior to implementation of the DOD Acquisition Improvement Program that are still designated major are being examined at the OSD level to determine whether more decentralization is desirable. To date, as a result of these examinations, the following delegations have been made to the services by the DSARC:

—Near-term scout helicopter—Milestone I decision
—Multi-mission destroyer (DDGX)—Milestone I decision
—Over-the-horizon backscatter radar (OTH-B)—Milestone II and III decisions
—Tomahawk cruise missile—Milestone III decision
—KC-135 re-engine program—Milestone III decision
—Hellfire missile—Milestone III decision

In addition to the programs already delegated to the services, similar decisions on approximately 15 more major programs are under active consideration. The administrative burden will be reduced on the programs delegated to the services, and the acquisition time may be shortened.

FIGURE 4
Programs Removed from DSARC Actions Because of the New Dollar Threshold Requirements to be Satisfied Before a Defense System Program Can be Designated as "Major"

Army Programs
- **Infantry Manportable Anti-Armor Weapon System (IMAAWS)**
- **Force Level Maneuver Control (FLMC)**

Navy Programs
- **Surveillance Towed Array System (SURTASS)**
- **Air Intercept Missile - AIM-7M (SPARROW)**
- **Landing Craft Air Cushion (LCAC)**
- **Intermediate Water Depth (IWD) Mine**
- **Landing Vehicle Tracked, Experimental (LVTX)**
- **Carrier On-Board Delivery Aircraft (VCX)**

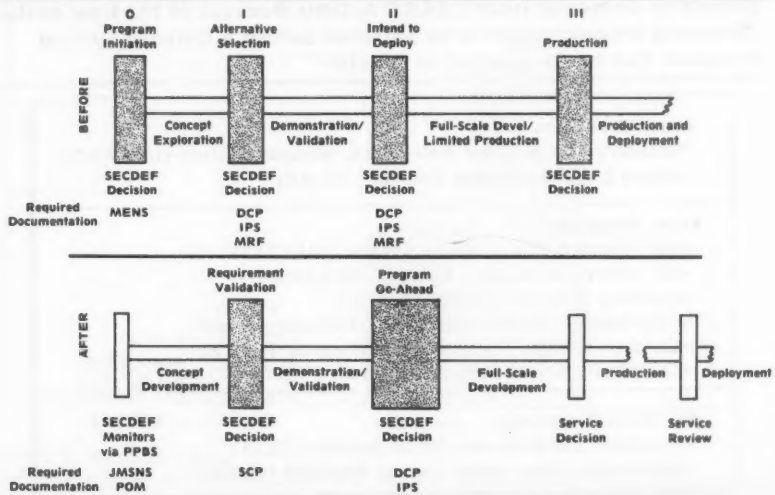
Air Force Programs
- **Precision Locating and Strike System (PLSS)**
- **Communications Nodal Control Element (CNCE)**

Changes to the Basic Process

The basic acquisition process, prior to implementation of the DOD Acquisition Improvement Program, provided four discrete SECDEF decision points (Figure 5). Implementation of Action 24 has resulted in the number of formal OSD milestone reviews being reduced from three to two, and the number of SECDEF decisions being reduced from four to two. Although the SECDEF has given up the Milestone 0 and III decisions, he has retained indirect control of both—Milestone 0 through the JMSNS/POM actions and Milestone III by reserving the right to hold a program review or to make a decision regarding production when a program breaches a previously established threshold.

The DOD Acquisition Improvement Program emphasizes the program manager's authority and responsibility to tailor his acquisition strategy to accommodate the unique features of the program. This is to be done, provided the strategy does not violate the basic logic for system acquisition problem-solving or the principles set forth in DOD Directive 5000.1 for business and management considerations. For example, the program manager recommends to the DSARC the timing of the Milestone II decision point. This recommendation is made when the DSARC is reviewing the program at Milestone I, preparatory to making a recommendation to the SECDEF to validate the requirement and to proceed with

FIGURE 5
Acquisition Process Milestones Before and After Implementation of the DOD Acquisition Improvement Program



the demonstration and validation phase. The Milestone II decision should be made when sufficient information is available on performance, cost, schedule, producibility, industrial base responsiveness, supportability, size of the risk, and affordability.

There are four changes to the basic acquisition process, resulting from the DOD Acquisition Improvement Program, that are deserving of special attention:

1. The Mission Element Need Statement (MENS), which documented major deficiencies and required consideration and approval by the SECDEF prior to program initiation, will no longer be used. In accordance with Action 25 of the DOD Acquisition Improvement Program, the mission need determination has been incorporated into the PPBS. The major deficiencies (or opportunities for improvement) will be documented in the DOD component's JMSNS, a document submitted to the SECDEF as a part of the POM. This procedure provides better integration of the acquisition process and the PPBS because "new starts" will be reviewed in the context of the full service/DOD budget formulation process. The SECDEF will provide appropriate program guidance in the program decision memorandum (PDM). He will also provide official sanction for a new program start and will authorize the DOD component, when funds become available, to proceed with the concept exploration phase of the acquisition process. The DOD budget submitted to the Office Management and Budget will acknowledge endorsement of the JMSNS by the OSD.

On a program involving more than one DOD component, such as the Advanced Medium Range Air-to-Air Missile (AMRAAM) program, a SECDEF decision memorandum (SDDM) will be issued to specify the lead DOD component and provide guidance on the responsibilities of the participating DOD components. The lead DOD component will assign a program manager and request that the participating DOD components assign a deputy program manager.

2. The first explicit decision by the SECDEF on a major defense systems program will occur at Milestone I. This milestone will represent a validation of the requirement against the preliminary evaluation of concepts, cost, schedule, affordability, and readiness objectives. SECDEF approval at this point will signify authorization to enter the demonstration and validation phase and develop the system sufficiently to support a Milestone II decision. The DSARC will base its recommendation to the SECDEF on a system concept paper (SCP), prepared by the concerned program office to identify alternatives. The SCP will be submitted to the DSARC in lieu of the decision coordinating paper (DCP), the integrated program summary (IPS), and the milestone reference file (MRF) that were prepared for submittal in the past. Included in the SCP, in addition to the program alternatives, will be a summary of the results of the concept evaluation phase, the objectives to be met at the next program milestone, the acquisition strategy recommended—including the nature and timing of the next SECDEF decision point—and a "not to exceed" dollar threshold to carry the program

through the next milestone. An SDDM is issued by the SECDEF following approval of Milestone I.

A Milestone I decision by the SECDEF authorizing a "delayed" Milestone II decision becomes an implied go-ahead to enter the early portions of the full-scale development phase of a program. However, a program may be delayed or terminated when there is a change in the requirement, a threshold is breached, the schedule is not met, and/or cost and technical difficulties arise that can't be overcome.

The reduction in the volume of documentation was directed by Action 17, Decrease DSARC Briefing and Data Requirements.

3. The second explicit SECDEF decision will occur at Milestone II (program go-ahead). Secretary of Defense approval of this milestone will signify authorization to proceed with full-scale development (FSD). The timing of the Milestone II decision will be flexible and will depend upon the tailored acquisition strategy approved by the SECDEF at Milestone I. In the traditional approach, Milestone II would have occurred when the program was about to enter the FSD phase. However, it may be desirable to delay this decision based upon the acquisition strategy briefed at DSARC I. The documents supporting the Milestone II decision are the DCP and the IPS. The DCP, a top-level summary document, identifies the alternatives, goals, thresholds, and costs. The IPS, which does not repeat data in the DCP, provides more specific information and a comprehensive summary of the program. The milestone reference file is no longer required. An SDDM is issued by the SECDEF indicating approval of Milestone II requirements.

The AMRAAM missile, the Near-Term Scout Helicopter, and the Seek Talk communications program have received approval to delay the Milestone II decisions. In the first two programs, Milestone II has been delayed until after preliminary design review; on the third program, Milestone II has been delayed until after critical design review. This procedure will ensure that more information is available when the time comes to make the program go-ahead decision.

If the manager of a major defense system program initiated prior to the DOD Acquisition Improvement Program—when the Milestone II was not "flexible"—wishes to propose a delay of a Milestone II decision, he may do so by preparing and submitting an SCP (containing the appropriate acquisition strategy) to, and receiving approval of, the Defense Acquisition Executive before his program enters the FSD phase.

4. The production decision (Milestone III) has been delegated to the DOD component heads, provided the program objectives and thresholds established at Milestone II and recorded in the decision coordinating paper and integrated program summary have not been breached. The DOD component heads have been strongly encouraged to redelegate their authority to the lowest level in the component organization at which a comprehensive view of the program rests. If the thresholds are breached, a formal program review at Milestone III by the DSARC may be required. When this occurs, a DCP and an IPS will be prepared to

describe the program changes since Milestone II and to establish new thresholds. The delegation at Milestone III is a part of the controlled decentralization plan and results from implementation of Action 24. In this case, it can reduce the administrative burden and, possibly, shorten acquisition time.

The revised DOD Instruction 5000.2 provides information about the contents of the documents used in DSARC milestone meetings and program reviews.[7] The formats of the documents to be used in milestone meetings and program reviews are contained in a memorandum from the Defense Acquistion Executive.[8] Also, the instruction points out that in addition to the formal milestone decision points described above, a less formal program review may be held at any point in the acquisition of a major defense system. Program reviews, held at the call of the Defense Acquisition Executive, are narrower in scope than the full DSARC assessments. The program manager is informed in advance of the purpose of the review and the type of documentation that is to be submitted. Direction resulting from a program review which changes a program goal, threshold, or other previously approved direction is documented in an SDDM. During the first year of the new administration, 12 program reviews and only one formal milestone review were held (Figure 6.)

Challenges Still Facing Service and Program Management

To fully implement the DOD Acquisition Improvement Program, service management and program managers will have to meet and overcome several challenges, for example:

—Service management will have to delegate more authority to managers of major defense systems programs. In turn, program managers will have to decentralize the principal functions within the program office, and delegate some of their work loads to capable subordinates.

—The services will have to become familiar with the new procedures associated with program initiation. The JMSNS and the service POM will have to be prepared and coordinated before authorization to start a new program is granted.

—Program managers will have to tailor program strategy to the peculiar needs of the program, giving particular attention to the flexibility now available in establishing the timing of the Milestone II decision. It will be possible to make the decision for program go-ahead (or termination) well after full-scale development has begun, provided there are good and sufficient reasons.

—All decision-makers, including program managers, will be held accountable for actions taken (or not taken). With the increased emphasis on controlled decen-

7. U.S. Department of Defense Instruction 5000.2, "Major Systems Acquisition Procedures," 1982 (draft).

8. Dr. Richard D. DeLauer, memorandum to the members of and advisors to the Defense Systems Acquisition Review Council, subject: "Major Defense System Acquisition Program Documentation Format," April 12, 1982.

FIGURE 6
DSARC Reviews Conducted in 1981

DSARC MILESTONE REVIEW

Joint Tactical Information Distribution System . . . Milestone II (Air Force)

DSARC PROGRAM REVIEWS

ARMY

M-1 Tank
Patriot Air Defense System
Stand-Off Target Acquisition System (SOTAS)

NAVY

Advanced Light-Weight Torpedo (ALWT)
F-18 Aircraft . . . 2 reviews in 1981
LAMPS Helicopter

AIR FORCE
CX Aircraft
Defense Satellite Communications System III (DSCS III)
Ground-Launched Cruise Missile (GLCM)
Space Defense System
Sparrow Missile (AIM-7M)

tralization, program decisions made by line officials above the program manager will require documentation with appropriate accountability.

Summary

With the implementation of the DOD Acquisition Improvement Program, there is an expectation at many levels within the services that authority will be delegated to a much greater degree than it was previously. Further, it is anticipated that the services will reduce the number of reporting and reviewing requirements, thereby freeing up program managers to carry out the tasks suggested by the Program.

One of the objectives of the changes to the defense systems acquisition process is to make it more effective and enable the process to proceed at a faster pace. If the services really want such changes, the Acquisition Improvement Program provides them with a vehicle for it. But the people in charge must be willing to be innovative, then follow it through. The new environment is a distinct change from the conservatism that has prevailed in the past. It can be simply stated as an open-mindedness to different strategies, an opportunity to articulate one's needs,

and a willingness of DOD management to try new approaches.

What can the program manager expect? To begin with, he can be innovative in planning his acquisition strategy. The success of his approach will be evaluated initially in the JMSNS (provided the program manager has been appointed prior to that time), then by the DSARC at Milestone I, and again by the DSARC at Milestone II. He will be given greater authority and responsibility in the new environment, and he will have more flexibility in managing his program. Commensurate with his authority and responsibility, he will be held accountable for his actions and the success (or failure) of his program.

Epilogue

We are convinced that the DOD Acquisition Improvement Program was intended to give managers an opportunity to carry out their assignments without being bogged down by unproductive tasks developed to satisfy an inflexible "system." The success of the program will be only as good as the senior- and mid-level managers in OSD and the services make it. "Business as usual" will not accomplish the program objectives. Responsible people in the acquisition process will make the DOD Acquisition Improvement Program work if they lead the way. ||

Design-to-Cost and the DOD Acquisition Improvement Program

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Major Raymond H. Barley, USAFR

The concept of design-to-cost is basically a simple one. Cost is established as a design parameter in the same manner as a performance parameter, such as speed, would be established.[1] The word "cost" when used in this article means the sum of development, production, operating and support costs.[2] This general definition of cost may be modified to fit various weapon systems.

Historically, design-to-cost contract clauses have been structured so that payments have been made at or near the completion of full-scale development (FSD).[3] The decision on whether or not the production cost goal has been met has generally been based on a design analysis done by the contractor and validated by the government. These studies estimate the production cost, sometimes several years into the future. These production cost projections are usually as optimistic as possible. In some instances, the actual costs have turned out to be higher than the original projections.

Action 22 of the DOD Acquisition Improvement Program is intended to make design-to-cost a more viable acquisition management tool. The mechanism for accomplishing this is to provide appropriate incentives to industry by associating fee awards to actual costs achieved during the early production runs. In that case, incentives would be paid for actual benefits that accrue to the government. They would not be payable based on paper activities, such as trade studies, where the actual cost benefit to the government may be questionable.

Application of Incentives

Design-to-cost incentives should be part of a comprehensive, coherent, and integrated incentive package that provides a continuing and consistent stimulus for the contractor to achieve all contract objectives. Design-to-cost incentives should be integrated with other incentives designed to ensure that reliability and maintainability requirements are also met. In this way both production and life-cycle cost objectives can be balanced.

The design-to-cost approach should be flexible enough to take into account deviations from original requirements, while preserving the integrity of the effort. Sometimes, significant deviations can result from actions external to the weapon acquisition itself. Areas in which significant deviations may occur include, but are not limited to: quantities, delivery schedules, configurations, and

1. AFLCP/AFSCP 800-19, "Joint Design-to-Cost Guide," 15 October 1977, p. 3.
2. *Defense Management Journal*, "Design to Cost," September 1974, p. 2.
3. Memorandum, "Improving the Acquisition Process," Frank C. Carlucci, Deputy Secretary of Defense, 30 April 1981, p. 24.

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government-furnished equipment/contractor-furnished equipment (GFE/CFE) mix. Procedures for accommodating these deviations should be negotiated concurrently with the initial design-to-cost requirements.

Incentive Structure

Design-to-cost incentives should be structured to provide:
—A financial reward to the contractor after a demonstration that actual costs are at or below the stated design-to-cost goals;
—Penalties to the contractor whenever the design-to-cost goals are not achieved.[4]

This incentive process is applicable to both sole-source procurements and competitive developments.

Sole-source situations require a different design-to-cost incentive process than competitive developments. In sole-source cases, rewards or penalties must be large enough to direct the contractor's attention toward attaining the design-to-cost requirements. Design-to-cost incentives should be based on all future costs, or cost surrogates, that result from the contractor's design decisions.

In competitive developments, the competitors are primarily interested in winning the follow-on activity. Therefore, to achieve design-to-cost motivation, future production and operating and support (O&S) costs should be made major elements of the selection criteria. If a contractor must meet design-to-cost requirements to be considered for future contracts, design-to-cost will receive major emphasis.

A Classic Example of Design-to-Cost

The F-16 fighter aircraft is a classic example of design-to-cost, in which design trade studies were used as the basis for the payment of the award fee. The F-16 multi-role fighter is a compact, high-performance aircraft designed for both air-to-air and air-to-surface combat.

F-16 DESIGN-TO-COST OBJECTIVE

A prime design-to-cost goal during full-scale development was to design to a cumulative average unit production flyaway cost of $3.8 million expressed in FY 1975 dollars for a total of 1,000 aircraft, at a maximum production rate of 15 aircraft per month. Unit production flyaway cost is defined as the sum of the cost of the basic airframe, a percentage of the basic unit for change allowance, propulsion, armament, electronics, non-recurring production costs, and other installed government-furnished equipment.[5] The contractor's proposed budgetary estimates of his portion of the unit production flyaway costs serve as the cost baseline against which deviations are reported.

4. DOD Directive 5000.28, "Design-to-Cost," Draft Directive Revisions, 27 October 1981, p. 9.
5. Department of the Air Force Contract No. F33657-75-C-0310, design-to-cost clause, p. 64.

The contractor was also expected to include the control of future downstream operating and support costs as a management objective during FSD. The government considered contractor requests for adjusting the design-to-cost goal at any time during the contract period, provided there was a real or demonstrable cost of ownership savings that resulted in an overall life-cycle cost benefit to the government. The contractor's proposal for adjusting the average unit production flyaway cost goal had to be supported by sufficient justification and data to substantiate a high degree of confidence that the life-cycle cost savings would be realized.

F-16 AWARD FEE

The contractor's performance in accomplishing life-cycle costs/design-to-cost (LCC/DTC) objectives was continuously monitored by the Fee Evaluation Board chaired by the Assistant Secretary of the Air Force for Installations and Logistics. The evaluation of the contractor's performance was based upon the completion of the LCC/DTC design trade studies. The maximum amount of award fee was $10.0 million broken down into three separate award fees as shown in Table I.

An initial award fee of $0.8 million was to be based primarily on the "Air Vehicle design cost reduction and opportunities guidance developed by the LCC/DTC design trade studies conducted prior to the Critical Design Review (CDR)."[6] An initial award of $275,000 was paid at the completion of the CDR. This is a classical design-to-cost situation, which is exactly what Action 22 is intended to prevent.

A second award fee of $2.4 million was to be based primarily on F-16 "Supportability including Aerospace Ground Equipment (AGE), training and maintenance, design cost reduction opportunities guidance developed by the LCC/DTC design trade studies [conducted] prior to the flight of the first Development Test and Evaluation (DT&E) aircraft."[7] A second award fee of $1.5 million was paid subsequent to the first flight of the development test and evaluation aircraft based on trade studies performed up to the first flight.

TABLE I
F-16 Award Fee Amounts

Amount		When Payable
$800,000	—	at completion of CDR
$2,400,000	—	subsequent to first flight of DT&E aircraft based on trade studies
$6,800,000	—	subsequent to operational test
$10,000,000		MAXIMUM AWARD FEE

6. Department of the Air Force Contract No. F33657-75-C-0310, award fee clause, p. 86.
7. *Ibid.*

A third award fee of $6.8 million departed from the classical approach in that it was to be based upon the demonstrated supportability of a selected group of components. This award fee was further divided into two separate fees of $0.4 million and $6.4 million. As of this writing, the $6.8 million has not been awarded. The award criteria for each of these fees are as follows:

—The $0.4 million award fee was to be based on the logistic support costs associated with the control first line units (FLUs). If the total measured logistic support cost–correction of deficiency (MLSC-COD) did not exceed the total target logistics support cost–correction of deficiency (TLSC-COD), then the contractor would be eligible for an award fee not to exceed $0.4 million.

—The $6.4 million award fee was to be based on the total logistic support costs associated with the non-control FLUs, excluding propulsion system FLUs and control FLUs covered under either the reliability improvement warranty (RIW) or correction of deficiency (COD) provisions. If the total MLSC-SYSTEM did not exceed the TLSC-SYSTEM, then the contractor would be eligible to receive an award fee not to exceed $6.4 million.

—A verification test was conducted from July through December 1981 to collect data to determine the contractor's eligibility for the $0.4 million and the $6.4 million award fees. The verification test was conducted by the Air Force using the first operational squadron. A total of 3,500 flying hours was accumulated. As of this writing, the Fee Evaluation Board has not convened.

Let's now consider some other programs that have used other design-to-cost approaches with greater emphasis on actual performance measured during initial production.

AV-8B Aircraft Design-to-Cost

The AV-8B aircraft is being procured by the Navy for use by the Marine Corps. This aircraft can make vertical takeoffs and landings and is an advanced version of the earlier AV-8A aircraft.

The design-to-cost objective consists of the following labor elements of the AV-8B aircraft: design engineering, tooling, production, and quality assurance. The design-to-cost objective is based on the prime contractor direct labor hours for three lots totaling 90 aircraft.[8] This negotiated design-to-cost objective is subject to adjustment, both upward and downward, if any of the following situations occur:

—The contractor revises the make or buy plan from the plan used for the AV-8B FSD aircraft.

—Changes are made to the contractor's system of accounting for direct vs. indirect personnel.

—A collaborative AV-8B GR MK 5 Program is entered into between the governments of the United States and the United Kingdom.

8. Department of the Navy, Contract No. N00019-79-C-0165, design-to-cost clause, p. 9–47.

—An adjustment is made in the cost of aircraft procured under the AV-8B contract as a result of engineering change proposals or specification change notices. No adjustment, however, will be made for changes issued for the correction of deficiencies.
—The government elects to procure aircraft at quantities or with delivery requirements other than those originally agreed upon.
—The government executes an advance procurement contract (in anticipation of a fully definitized contract) at dates different than those specified in the original delivery schedule.

ADJUSTMENT OF FEE

The design-to-cost objective of the prime contractor direct labor hours will be used for adjusting the fee. The procedures for determining the variations from this objective and the method for adjusting the fee are as follows:

At the appropriate time, the contractor will submit to the procuring contracting officer (PCO) a statement of the actual direct labor hours. If the design-to-cost actual prime contractor direct labor hours are less than the design-to-cost objective, then the incentive fee will be increased by the amounts specified in Table II.[9] The incentive fee is increased for every 1 percent less than the design-to-cost objective. In no event will the amount of the increase in the incentive fee exceed $10 million, nor will the maximum total fee exceed 13 percent of the target cost.

If the design-to-cost actual prime contractor direct labor hours are greater than the design-to-cost objective, then the incentive fee will be reduced by the amounts specified in Table III.[10] The incentive fee is decreased for every 1 percent that the design-to-cost actual prime contractor direct labor hours are greater than the design-to-cost objective. In no event will the amount of the reductions in the incentive fee exceed 10 million nor will the minimum total fee be less than 2 percent of the target cost.

The AV-8B aircraft (in full-scale development) will use up to ±$10 million fee adjustment against the direct labor hour target for the first 90 aircraft to be pro-

TABLE II
Fee Schedule - Contractor Exceeds Objective

Percentage Range Under	Fee Increase Per 1% Increment
0% to 5%	0
6% to 10%	$250,000
11% and up	$500,000

9. Department of the Navy, Contract No. N00019-79-C-0165, adjustment of the fee clause, p. 9–49.
10. *Ibid*, p. 9–50.

TABLE III
Fee Schedule - Contractor Fails to Meet Ojective

Percentage Range Over	Fee Decrease Per 1% Increment
0% to 5%	0
6% to 10%	$250,000
11% and up	$500,000

duced (three lots). An incentive fee will be paid after the delivery of the last lot of aircraft.

MX Missile

The MX missile is an intercontinental ballistic missile (ICBM) with improved accuracy and survivability. A design-to-cost incentive clause is being employed in the development contracts for the following subsystems of the MX missile: the four missile stages, the guidance and control system, and the re-entry system.

DESIGN-TO-UNIT PRODUCTION COST

The design-to-unit production cost (DTUPC) target and the formula to be used for determining the incentive were negotiated very early on in the development contracts. Target costs and profits will be negotiated in the normal fashion in the subsequent production contracts for each of the subsystems.

In the production contracts, the target cost will be reduced by the value of the non-incentivized items (i.e., non-recurring items), de-escalated to the same fiscal-year dollars as the unit production cost target, and adjusted for changes in production rates or quantities. This adjusted negotiated target cost, when divided by the quantity being procured, yields a negotiated average unit production cost. This negotiated average unit production cost, when divided by the unit production cost target established in the development contract, becomes the yardstick for calculating the incentive to be paid, as shown in Figure 1. The following paragraphs explain the mechanism for calculating the incentive payments.

In Figure 2, the ratio of the negotiated average unit production cost, divided by the unit production cost target, is plotted along the horizontal axis. The vertical axis provides the rate used to determine the incentive profit dollars. If the target production costs are negotiated at a level that will yield a negotiated average unit production cost (UPC) that is less than the unit production cost target established during the development program, the contractor's negotiated target profit will be increased, as shown in the upper left-hand quandrant. If the negotiated average unit production cost exceeds the unit production cost target, the target profit will be reduced, as shown in the lower right-hand quandrant. As

I will explain shortly, this rate is only a factor used in the incentive calculations and should not be confused with the overall contract profit rate.

Figure 3 provides some hypothetical data that can be used as an example. Let us assume that a unit production cost target has been set at $1.1 million and the production contract has been negotiated as shown—the target cost is $100 million, the target profit is $10 million, and the quantity is 60 units.

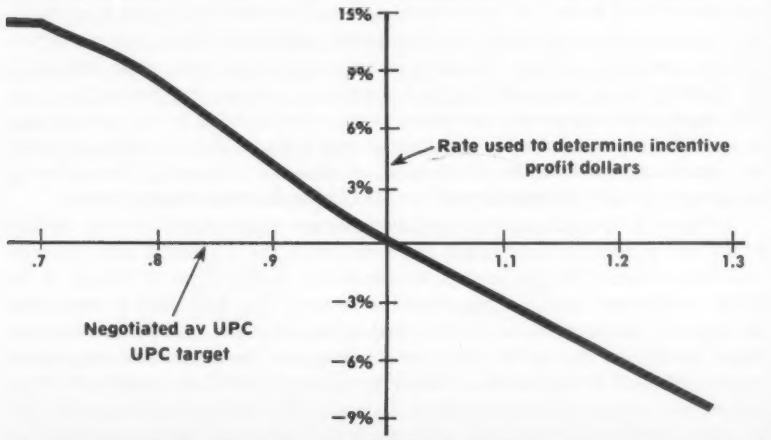
Figure 4 illustrates the actual incentive calculations. First, the negotiated target cost is reduced by $30 million, which represents the non-recurring cost for tooling and start-up charges that are not included in the incentive arrangements.

FIGURE 1
D-T-C Sample Application - MX Program

- **Production contract**
  - **—Negotiate target cost and profit**
  - **—Allocate and adjust target cost** ▶ **"Negotiated Average UPC"**
  - **—Calculate incentive**

$$\text{Yardstick} = \frac{\text{Negotiated Av. UPC}}{\text{UPC Target}}$$

FIGURE 2
D-T-C Incentive Formula for MX Program



Then, the effects of inflation are accounted for in the calculation by de-escalating the $70 million to $60 million (same fiscal year dollars as design-to-to unit production cost target). The $60 million is then divided by the 60 units being procured in the first production lot to arrive at a negotiated average unit production cost of $1 million. This negotiated average unit production cost of $1 million is divided by the unit production cost target of $1.1 million to yield a ratio of .9. Using the formula and the graph in Figure 2, this ratio yields a positive incentive rate of 4 percent. This 4 percent rate is applied to the $60 million incentivized and de-escalated portion of the total contract to yield a profit gain of $2.4 million. When added to the original target profit of $10 millon, the new total target profit becomes $12.4 million, which, when related to the negotiated target cost of $100 million, yields a rate of 12.4 percent.

As of this writing, the MX missile has been in the development phase since 1978. The production contract will not be negotiated until approximately the summer of 1983.

FIGURE 3
D-T-C Example - MX Program

ASSUME: —UPC target set at $1.1M
—First production contract negotiated
Target cost - $100M
Target profit - $10M
Quantity - 60 units

FIGURE 4
D-T-C Example Calculation - MX Program

Then:

1. $100M - neg target cost
   −30M - Non-incentivized portion
   $70M De-escalate $60M
2. $\frac{\$60M}{60 \text{ units}} = \$1M$ Negotiated Av. UPC
3. $\frac{\$1M}{\$1.1M \text{ UPC target}} = .9 \blacktriangleright$ + 4% profit adjustment
4. $60M × 4% = $2.4M Profit gain
5. Target profit = $10M + 2.4M = $12.4M

Army AN/TPQ-36 Firefinder Program

The design-to-cost contractual arrangement was utilized on the Army's AN/TPQ-36 Firefinder, a radar system used to locate the source of incoming enemy mortar fire and to adjust friendly fire.

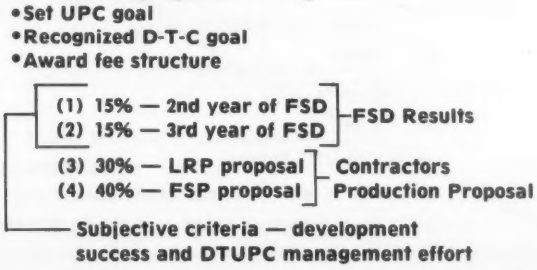
During the development program, the unit-production-cost goal was established with the contractor. This development contract also included a recognized and separately funded design-to-cost management effort. It was this effort that paid for the various design trade studies and ensured that cost was adequately considered during the program decisions.

An award-fee structure was also established in the development contract, as shown in Figure 5. The total award fee was divided into four increments. The first two increments, which were each valued at 15 percent of the total possible fee, were payable during the second and third years of the development program. These two increments were based upon the Army's subjective evaluation of the contractor's technical achievements and his design-to-cost program efforts. The third increment of fee was to be based on the hardware production costs as contained in the contractor's low-rate production (LRP) proposal. The fourth and largest increment of fee was to be based on the contractor's full-scale production (FSP) proposal.

During the development effort, Firefinder underwent major design and program changes. The acquisition strategy was altered to eliminate the low-rate production phase and to go directly into a multiyear, full-scale production program.

As shown in Figure 6, the design-to-cost goal negotiated in the development contract prior to the major program and design changes was $534,000, which was the goal for unit costs in full-scale production. Because major design and program changes were made, the design-to-cost goal was adjusted upward from $534,000

FIGURE 5
D-T-C Example - Army Firefinder Program


Development program:
•Set UPC goal
•Recognized D-T-C goal
•Award fee structure
(1) 15% — 2nd year of FSD
(2) 15% — 3rd year of FSD
FSD Results
(3) 30% — LRP proposal
(4) 40% — FSP proposal
Contractors Production Proposal
Subjective criteria — development success and DTUPC management effort

to $702,000. The contractor proposal for full-scale production called for $695,000 per unit. The design-to-cost goal was subsequently negotiated to a unit production cost of $642,000, down from $702,000. (All of these figures are in FY 73 dollars.)

Based on these program results, the fees shown in Figure 7 were actually awarded. Of the $850,000 maximum total fee available, a maximum of 15 percent, or $127,500, was possible as the first increment originally scheduled for August 1975. A fee of $119,850 was actually awarded in December 1975, based on a subjective evaluation of the contractor's technical progress on the program and his design-to-cost management program efforts. Likewise, $26,760 was awarded for the second increment in January 1977.

The leftover fee was rolled forward to increase the amounts available to be awarded at the third and fourth increments. Because the program was restructured to go directly into full-scale production, the third and fourth increments were combined and were awarded based on the full-scale production proposal. As shown, $703,390 was awarded in March 1979, bringing the total fee awarded up to the maximum of $850,000 originally made available.

As shown in Figure 8, the key features of this design-to-cost program approach were as follows:

—The separately identified and funded management program for the purpose of implementing and integrating the principles of design-to-cost was considered as having played a key role in the success of this program.

—The application of the design-to-cost goals and the entire design-to-cost program was flexible enough to accommodate changes in the basic program while still maintaining the integrity of the initial design-to-cost goal. When changes were made in the basic program the design-to-cost program was adjusted at the same time to keep "in step."

—The design-to-cost goals and incentives were structured and integrated into the contract so that they would not conflict with other incentives and, in fact, complement each other as much as possible.

FIGURE 6
History of Firefinder D-T-C Goals (FY 73$)

Prior to changes	
DTC goal	534K
Subsequent to changes (program & design)	
DTC goal	$702K
FSP proposal	695K
FSP negotiated	642K

—The incremental assignment of award fees to the development program and the production program incentivized both efforts, which were, of course, extremely important in the accomplishment of the design-to-cost objectives. Incentives during the development program were introduced when the critical design trade-off decisions were being made. Incentives based on actual production costs reflected the basic thrust of Acquisition Improvement Program Action 22; that is, to reward actual performance.

M-712 Copperhead Projectile

The M-712 Copperhead is a 155 millimeter cannon launched guided projectile (CLGP), which employs a laser-seeking guidance system. The on-board computer continuously refines the terminal trajectory and provides guidance to the control surfaces, causing the CLGP to home in on the laser-designated target.

DESIGN-TO-UNIT PRODUCTION COST

The contractor was required to design and develop the Copperhead at a specific unit cost, which was referred to as the design-to-unit production cost. The DTUPC was based on recurring costs for major system equipment and those cost elements that were identified as contractor related costs: quality control, manufacturing (including subcontract), engineering, recurring tooling, general and administrative, and profit. The DTUPC established by the government presupposed full achievement of all performance requirements by the contractor.

FIGURE 7
Firefinder D-T-C Award Fees Granted

$850K Total max
1. 15% max ($127,500) Aug 75 ($119,850 Dec 75)
2. 15% max ($127,500) Jun 76 (26,760 Jan 77)

3. 30% max ($255,000) LRP proposal
4. 40% max ($340,000) FSP proposal

($703,390 Mar 79)

FIGURE 8
Key Feature of Firefinder D-T-C Program

—Management program
—Flexibility — change with program
—Integration with other incentives
—Incremental award of fees

AWARD FEE

An award fee was to be paid to the contractor for achieving or bettering the DTUPC. Table IV shows the maximum award fee available for each of the indicated periods; however, any amount not awarded during any of the designated award periods could be earned in a subsequent period.[11]

As a condition before payment of the fourth award fee, the contractor will have to submit the actual production cost data observed during production.

The amount of award fee to be paid to the contractor was to be determined unilaterally by the government. At the time specified under contractor/demonstration, if the government evaluation showed that the contractor was making adequate progress toward designing the Copperhead consistent with the requirements of the contract, the contractor could be paid an award fee. When determining the amount of the award fee to be paid, the government would consider the long-term impact of contractor trade-offs to achieve the DTUPC.

When the contractor submitted a cost estimate to the government, the DTUPC estimate was de-escalated from current-year (then-year) dollars to a base year (constant FY 75 dollars). The government unilaterally computed an evaluated DTUPC achievement before computation of the fee to be paid. The contractor has been paid three award fees thus far: $75,000, $95,000, and $175,000, for each award period, respectively.

Cruise Missiles

There are four types of cruise missiles: sea launched cruise missile (SLCM), ground launched cruise missile (GLCM), air launched cruise missile (ALCM), and

TABLE IV
Maximum Award Fee

PERIOD	CONTRACTOR/DEMONSTRATION	AWARD FEE	PERCENT OF TOTAL
First	Second Quarterly Review Meeting approximately 7 months after award of contract.	$200,000	10
Second	Initial Design Freeze, approximately 17 months after award of contract.	$200,000	10
Third	Final Design Freeze, approximately 25 months after award of contract.	$500,000	25
Fourth	Upon verification that the initial production contract contract CLGPs meet the system performance requirements.	$1,100,000	55
		$2,000,000	

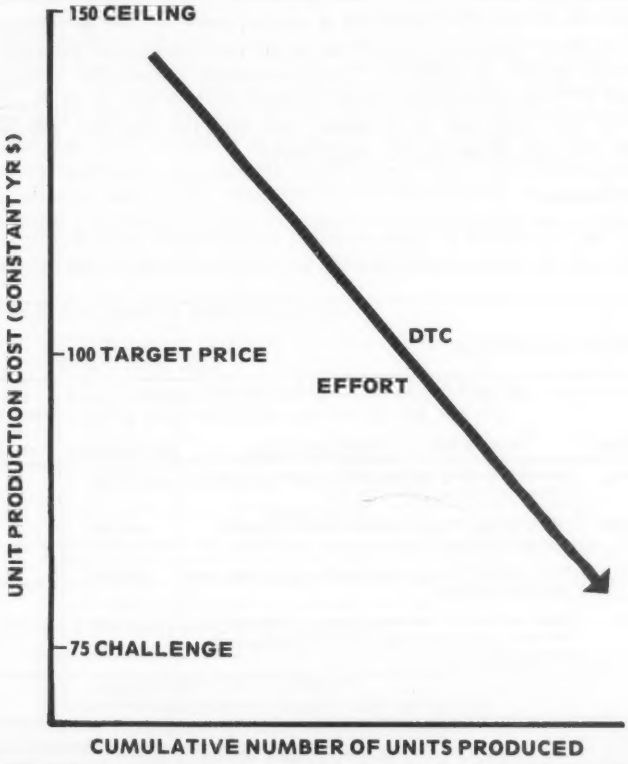
11. Department of the Army, Contract No. DAA09-76-C-2001, award fee clause, p. 24.

medium range air to surface missile (MRASM). They are powered in flight by a turbo-fan engine. The ALCM and MRASM are air launched, while the other two are surface launched with the assistance of a rocket booster motor.

CRUISE MISSILE DESIGN-TO-COST PROGRAM

The following is a general discussion of the cruise missile design-to-cost program. The objective of this program is to develop a cruise missile with both minimum unit gross flyaway cost and minimum ownership costs, while still meeting all essential system requirements. Unit gross flyaway costs include all direct and indirect contract costs including contractor profit; all recurring and

FIGURE 9
Cruise Missile D-T-C Challenge and Ceiling



non-recurring production contract costs; and all flyaway cost as defined in DODI 5000.33. This definition excludes all costs associated with the production of peculiar support equipment, data, training, operational/site activation, and initial spares.

DESIGN-TO-COST CHALLENGE/CEILING COST

The design-to-cost challenge and ceiling are mutually agreed upon by the contractor and the government at the beginning of the development contract. The design-to-cost challenge and ceiling are based on actual production costs on similar programs.

The design-to-cost challenge is defined as a difficult, but attainable, cost objective. The design-to-cost ceiling is defined as the upper cost limit, beyond which the unit cost is unacceptable. The ceiling is also the affordability limit. As shown in Figure 9, the challenge and ceiling define the "window" within which the contractor's costs will be tracked.

The maturity of the production line is measured as a function of the cumulative number of units produced. The curve will go down, because the unit cost decreases as the contractor becomes more adept in producing missiles. The objective is to make the learning curve steeper as a result of a conscious design-to-cost effort to reduce the unit production cost. All of the unit costs are averaged out over the entire production run. The target price is the expected price. It is expected that this average unit production cost will fall somewhere close to the target price. The average unit production cost is expressed in some base-year dollars, which excludes inflation.

AWARD FEE

The award fee payments are made at the end of the performance evaluation period. The fee determination officer decides how much award to grant based on information furnished by the performance evaluation board. When the award is made, it is unilateral and not subject to dispute by the contractor.

Analysis

There are advantages and disadvantages associated with Action 22. The principal advantage is that the awarding of a fee would be based on actual production costs achieved. This ties the award to "real" achievement. It moves away from basing awards on paper studies that attempt to establish expected costs.

The disadvantages mostly arise from delaying the payment of the award. The delay may tend to reduce the impact of the incentive; thus, some of the very motivation that Action 22 is intended to achieve in the design process would be lost. Another consideration resulting from the delay is that it would allow time for more program changes that could complicate the fee-determination procedure. Furthermore, it could inhibit a harmonious relationship with the contractors by supplying an area of disagreement.

Summary

This article has examined six weapon systems with respect to the concept of design-to-cost. No two systems are exactly the same regarding how design-to-cost was used. There are marked differences in what the unit production cost award was based on. There are also differences in the method of determining how and when the fee would be awarded. As of this writing, some of the systems are still in production, and not all projected fee awards have been made.

These are just some examples of how the design-to-cost concept has been, and is currently being, applied. They are not purported to be the "right way" of doing business. They are merely intended to provide program managers and procuring contracting officers with concepts they may use as part of their own acquisition strategies.

Table V summarizes the six weapon systems and their different design-to-cost approaches. The table ranges from classical design-to-cost, typified by the F-16, to the method espoused under the DOD Acquisition Improvement Program.

Conclusion

The Acquisition Improvement Program challenges program managers and contracting officers to develop contract terms and procedures to provide for the payment of design-to-cost awards and incentives based upon costs actually achieved during early production runs. Payments must be based upon a

TABLE V

SYSTEM	APPLICATION	UPC GOAL BASED ON:
F-16	UPC/LCC	—design trade studies at CDR —LCC Awards (2) based on studies and actual experience.
AV-8B HARRIER	UPC	—Prime contractor direct labor hours —First 90 production aircraft
MX MISSILE —4 Missile Stages —Guidance & Control System —Re-Entry System	UPC	—Contractor's production proposal
AN/TPQ-36 FIREFINDER	UPC	—70% — contractor's production proposal —30% — FSD results
M-712 COPPERHEAD	UPC	—55% — initial production results —45% — during FSD
CRUISE MISSILES	UPC	—Both cost ceiling and challenge at beginning of development contract —Actual production costs on similar programs

demonstration that initial costs are on track with a design-to-cost goal for the total forecasted production.

Contractors will respond to appropriate incentives based on realistic design-to-cost requirements. Careful consideration must be given as to what factors to include: schedules, quantities, rates, inflation indices, etc. The intent of design-to-cost is to encourage the contractor's development team to include some production-cost considerations earlier in the program than they normally would in order to develop a good design-to-cost goal. The role of the contractor in design-to-cost is crucial, because the contractor is the one ultimately doing the design work. Making cost a primary design objective cannot be accomplished without the contractor's commitment. ||

Enhanced Multiyear Procurement for Improving Weapon Systems Acquisition

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Dr. Abraham Singer
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In 1980 congressional testimony, General Alton D. Slay, then Commander of the Air Force Systems Command, characterized enhanced multiyear procurement (MYP) as "the single most important change we can make to address the defense industrial base problems. It is the *key* because it attacks so many problems . . . and attacks them so well."[1]

In 1981, after a comprehensive internal review under the direction of the Deputy Secretary, the Department of Defense issued a package of 32 actions aimed at significantly improving the DOD acquisition process. The actions are collectively known as the DOD Acquisition Improvement Program. The most important element in that package is the action dealing with enhanced multiyear procurement. It alone is expected to yield an average dollar savings of 10 to 20 percent in unit procurement cost through improved economies and efficiencies in production processes, economy-of-scale lot buying, decreased financial borrowing, better utilization of industrial facilities, and a reduction in the adminstrative burden in the placement and administration of contracts.[2]

In addition, enhanced MYP overlaps a number of other major actions in the package, particularly those relating to the improvement of the defense industrial base. Specifically, (1) enhanced MYP is expected to stimulate investment in production equipment which in turn will result in lower-defect, higher-quality products, and (2) it will provide increased program stability, which will enhance the continuity of subcontractor supply lines and thereby decrease the acquisition time.[3]

1. Capability of U.S. Defense Industrial Base, Hearings before the Committee on Armed Services and the Panel on Defense Industrial Base of the Committee on Armed Services, House of Representatives, 96th Congress, Second Session, 1980, p. 620.
2. Caspar W. Weinberger, Secretary of Defense, speech to the Tax Foundation, 2 December 1981.
3. Frank C. Carlucci, Deputy Secretary of Defense, DOD Memorandum, "Improving the Acquisition Process," 30 April 1981; Carlucci, Policy Memorandum on Multiyear Procurement, 1 May 1981.

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This paper will examine multiyear procurement in a manner understandable to those outside the procurement field. Specifically, we will address the following: To what extent has MYP been practiced so far? What are the major deficiences in classical MYP? What are the major elements of enhanced MYP, and what are their associated benefits and disadvantages? And what are the criteria for implementing enhanced MYP?

Background

An effective way to introduce the concepts and terminology of multiyear procurement is by means of an example. Consider therefore the following hypothetical case:

Suppose that in 1976 the Army decided it had a requirement for 500 new tanks. Based on considerations such as how long it would take to produce the tanks, how long it would take to phase them into the existing Army structure, the projected availability of funds, the relative priorities within the Army, etc., the Army decided to "buy" (i.e., enter into contractual agreement for the production of) the tanks on the following schedule.

FY	*Tanks*
1978	65
1979	95
1980	100
1981	125
1982	115
	500

Procurement Jargon

It is important to note that in procurement jargon the 65 tanks the Army scheduled to "buy" in 1978 are called the 1978 requirement. This is a simple but key concept because it provides the underpinning for a number of other important procurement concepts in current use.

Let us assume that the Army identified the tank requirement in its five-year defense program (FYDP), that it was approved by the Secretary of Defense and by the Office of Management and Budget (OMB), that the President's 1978 budget contained a request for funds to cover the estimated cost of the 65 tanks, and that in 1978 Congress appropriated the funds for producing the 65 tanks.

Since Congress appropriated funds for only a single year's tank requirement, this is called *annual funding.** In appropriating the funds, however, Congress

*We will use intuitive, or informal, definitions in the text, relegating the precise definition to Appendix A. The definitions conform to the terminology enunciated by the Deputy Secretary of Defense in his May 1, 1981, policy memorandum on multiyear procurement.

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provided sufficient money to cover the total estimated cost to deliver 65 complete, militarily usable tanks. This is known as *full funding*. A test of full funding is to ask the question, "Does any part of this year's buy depend on a future year's appropriation to result in the delivery of complete units?" If the answer is yes, it is probably not full funding. Full funding is a policy that Congress has followed for over a decade in appropriations for production contracts (but not RDT&E contracts). This policy is reflected in OMB Circular A-11 and DOD Directive 7200.4.

Because the Army had 3 years to obligate the funds (enter into a contractual agreement wherein these funds are used to cover the production of the tanks), they are known as 3-year funds (or, sometimes, as 3-year appropriations). If part or all of the funds are not obligated after 3 years, the unobligated portion is "lost" to the executive branch in that it reverts back to the U.S. treasury. Once obligated, however, there is no statutory time limit for their expenditure.

At this point it may be worth emphasizing the distinction between the two similar sounding terms, multiple-year funds and multiyear funding. Although both operate in the time domain, they refer to entirely different concepts. The former refers to the length of time the executive branch has to obligate appropriated funds, whereas the latter refers to the appropriation of funds by Congress for more than one fiscal year's requirements at a time.

Returning to our hypothetical example, the Army sent out requests for proposals (RFPs) for producing the 65 tanks and awarded the contract to the lowest qualified offeror. Since the contract covers one year's requirements only, it is known as a single-year contract.

Again we must emphasize that, although it might have taken the Army as much as 3 years (until 1981) to obligate the funds, and the first tank may not arrive until 2 years later (1983), and the last dollar of the 1978 appropriation may not be expended until 1985 with the arrival of the 65th tank, the process is still called a one-year buy, the contract is called a single-year contract, and the congressional appropriation is called annual funding—all because they relate to a single year's requirement.

Suppose that at some point before the delivery of all 65 tanks, the threat changes significantly or there is a technological breakthrough that makes these tanks obsolete. At any time during the life of the contract, the government, as the sovereign, has the unilateral right to end the contract. When the government exercises that right, it is called *termination for convenience*. The government is, of course, obligated to compensate the contractor—in accordance with the provisions of the contract—for the allowable expenses he incurred up to that point in the process of executing the contract, as well as for the expenses involved in implementing the termination. This cost to the government is called the *termination charge*, and the maximum termination charge is called the *termination liability*.

Long Lead Time Items and Economic Order Quantities (EOQ)

In our simple example, even if the Army had succeeded in obligating the funds for the 65 tanks in 1978, it would probably not take delivery of the first tank of this buy until late 1980 or early 1981 owing to the time lost in waiting for long lead time components. The question then arises, why incur similar time losses in the subsequent years' buys? In other words, why not order in 1978 the long lead time components for, say, the 1979 and 1980 buys? Such an exception to the full funding policy, called *advance long lead procurement* and considered one form of *advance procurement*, is indeed authorized under DOD Directive 7200.4. It may include "materials, parts and components, as well as cost associated with the further processing of those materials, parts and components." Until recently, however, it has usually been limited to 1 year ahead of the scheduled requirements. In 1978, therefore, the Army could order the long lead time components for the 1979 requirements, but not for the subsequent years. It may be worth noting here that advanced long lead procurement in support of a single year's requirements is not considered multiyear procurement. It should also be noted that the congressional authorization committees have been expressing concern at the growth of advance procurement funds from over $600 million to over $1 billion during the 1976–80 time period.

It would appear that by buying, in 1979, some components and subsystems for, say, the 1980 and 1981 requirements, the Army should be able to realize substantial savings from economies of scale. As a matter of fact, studies (substantiated by experience in the 1960s) indicate that the savings could be as high as 10 to 20 percent. However, until recently—the passage of the 1982 DOD Authorization Act—DOD could not take advantage of such economic order quantities because of statutory restrictions.

"Single-Year" Contracting

Let us assume now that each year Congress appropriated the funds for the Army tank requirements outlined earlier. If this were not a major system, the rest of the process would probably have been repeated in a similar way; i.e., the Army would compete each year's buy and award the contract to the lowest qualified offeror. Since this *is* a major system, a somewhat modified strategy was applied. Based on actual practice, the most common contract strategy has been a one-year production contract (probably a single-source buy following competitive FSED) which includes a series of options. This can also be said to be "annual" contracting or "single-year" contracting in that quantities are authorized and funds appropriated annually and, in turn, the option is exercised annually. Under the funding rules prior to P.L. 97-86, the contractor could only build and order materials for one fiscal year's quantity (except for long lead or to the extent he wished to work on out-year requirements at his own risk).

The DOD, industry, and even the General Accounting Office (GAO) agree that this type of "single-year" contracting for buying 500 tanks is a very inefficient approach. Yet, this has been by far the most common type in DOD for production contracts of major systems. This brings us to the subject of classical multiyear procurement, i.e., multiyear procurement as it has been practiced during the last decade or so.

Classical Multiyear Procurement

In our simple example, consider an alternative contracting strategy, wherein in 1978, after Congress appropriated the funds for that year's requirements, the Army competed and then awarded a single five-year contract for the entire 500-tank requirement, contingent, of course, on Congress appropriating the necessary funds for the 1979 and subsequent years' requirements. Now suppose that in 1979 Congress failed to appropriate the funds for that year's requirements—because, say, the threat had changed—and indicated that it is highly unlikely to fund the subsequent years' requirements.

As a result of this congressional action the Army had no choice but discontinue contractual performance for 1979 and beyond. This is called *cancellation*. Had the Army decided, as a result of congressional guidance to also reduce the 1978 buy from 65 tanks to, say, 45 tanks, the action would have been referred to as *termination*.

Note that there is a difference between "cancellation" and "termination." Cancellation is a term unique to multiyear contracts; is usually effected only between fiscal years (as a consequence of congressional action); and applies to the total subsequent fiscal years' quantities. Termination, on the other hand, is a much broader term; applies to any government contract, single or multiyear; can be effected any time during the life of the contract; and applies to the total or partial quantity.

As a result of the cancellation action, the Army compensated the contractor for certain unrecovered costs incurred in conjunction with the 1979–83 buys. The amount paid by the government to the contractor is called the *cancellation charge*, and the maximum cancellation charge by law that the government can pay in conjunction with any one multiyear contract is known as the *cancellation ceiling*.

Actually, had the Army indeed decided to pursue a multiyear strategy in the procurement of 500 tanks and in 1978 issued an RFP for a 5-year production contract, the likelihood of getting any qualified proposals would have been extremely small. As a matter of fact, the likelihood would have been almost as poor even for the case of, say, a 2-year contract. This is borne out by the fact that only a minute fraction (about 1 percent) of the Army's production expenditures in recent years has been through multiyear; the Air Force and Navy have similar records.

The question is, why has there been such a high reluctance on the part of industry to enter into multiyear contractual agreements, in spite of obvious potential advantages of MYP to both government and industry? The basic reason hinges on the high risk, real or imagined, that industry has been associating with MYP. Two major factors contributing to that risk—as identified by the overwhelming majority of witnesses testifying at the 1980 congressional hearings on the U.S. industrial base—have been the magnitude and scope of the cancellation ceiling.[4] Until recently, the cancellation ceiling has been $5 million, and it covered only non-recurring costs.

Multiyear Funding

A question might come to mind at this point: Since the Army, DOD, OMB and the President have all agreed that the Army has a requirement for 500 new tanks, why didn't Congress in 1978 appropriate the funds for the entire 500 tanks, thereby giving the Army the flexibility to procure the tanks in the most economical way possible? Had Congress appropriated funds to cover more than one year's requirements, the appropriation process would have been called multiyear funding (MYF). And, indeed, during recent years the Electronics Industries Association, as well as some high-level officials from major defense contractors, have been lobbying for multiyear funding. Even GAO in 1979 supported this concept for major weapon systems acquisition, and in a 1981 report widened that support to R&D.[5]

Although the Defense Science Board (DSB) in 1979 advocated multiyear funding, it backed away from the concept in 1980 on the grounds that MYF would "exacerbate the current 'bow wave' problem" in funding, and advocated instead the use of enhanced multiyear procurement.[6] Recently, industry has also backed off from multiyear funding and adopted enhanced multiyear procurement as a fall-back position, chiefly because of the realization that Congress is highly unlikely to approve multiyear funding in the forseeable future and that enhanced multiyear procurement (with a high cancellation ceiling) can accomplish almost as much as multiyear funding.

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4. Congressional Hearings, 1980, pp. 844, 913, 989.

5. Congressional Hearings, 1980, p. 989. See also, for example, letter from G. M. Skula, Chairman of the Board and President of Grumman Aerospace Corporation, to Rear Admiral N. P. Ferraro, Naval Air Systems Command, 16 April 1980; Report by the Comptroller General of the United States, "Review of the Department of Defense's Implementation of Procurement Reforms," PSAD-79-106, B163058, 25 September 1979 (released, 9 October 1979); Report by the Comptroller General of the United States, "Multiyear Authorizations for Research and Development," DAD-81-61, B-202294, 3 June 1981.

6. Report of the Defense Science Board 1979 Summer Study of "Reducing Unit Cost of Equipment," March 1980; Report of the Defense Science Board 1980 Summer Study Panel on "Industrial Responsiveness," January 1981.

Implementation of Enhanced Multiyear Procurement

Congress

By passing the 1982 Department of Defense Authorization Act, Congress has removed the basic statutory impediments to enhanced multiyear procurement. First, the Act virtually eliminates the cancellation ceiling: DOD can now award multiyear contracts carrying cancellation ceilings up to $100 million each (as compared to only $5 million before); contracts having higher ceilings require congressional notification (to the Armed Services and Appropriation Committees in both houses) at least 30 days prior to contract award. Second, the Act broadens considerably the coverage of the cancellation ceiling to include recurring costs (e.g., for out-year components, parts and work-in-process) as well as for nonrecurring costs (e.g., for start up and preproduction), and allows for economic lot buys. And third, the Act allows advance buys—both in the case of long lead time components and economic order quantities—for more than 1 year beyond the current year's requirements. (In addition, the Act also broadens the provisions of Public Law 90-378, authorizing multiyear procurement with annual funds for supplies and services in the continental United States.)

Congress also approved three of the four MYP candidates—the C-2A, F-16, and AN/TRC-170 radio—proposed by DOD for FY 1982. (Congressional approval was required here because reprogramming actions were involved.) The MYP on these three programs alone is expected to result in a saving of $325 million over single-year procurement. Adopting a cautious approach, the Secretary of Defense has required production and long lead time items on these programs to be fully funded in FY 1982, but allowed economic-order-quantity purchases to be funded to termination liability out of a special multiyear contracting increment to the total obligation authority (TOA).

Executive Branch

Congress has done its part by passing the 1982 DOD Authorization Act. The ball is now in the executive court. The executive branch must now work out the policy and administrative machinery for successfully implementing multiyear procurement. This process has already started with the launching of an intense effort to revise the pertinent procurement regulations: The Under Secretary of Defense for Research and Engineering (USDR&E) and the OSD Comptroller are working with OMB in modifying OMB Circular A-11, the Defense Acquisition Regulations (DAR) Council (part of OUSDR&E) established a subcommittee dedicated to revise DAR 1-322, and the OSD Comptroller is revising DOD Directive 7200.4. Furthermore, the Deputy Secretary of Defense issued new policy guidance on multiyear procurement; the services have initiated the implementation of the FY 1982 major multiyear procurements (examples of relatively recent multiyear actions, involving either classical or enhanced MYP procedures, are

provided in Appendix B); the services have also examined their long-term, stable production programs and submitted FY 1983 multiyear candidates through the POM process (see Appendix C); and the PPBS system is being modified to provide stability for programs selected by the Secretary of Defense for multiyear procurement.

But we are still far from a functioning MYP environment. Some major issues that must yet be resolved concern the scope of the cancellation ceiling, the degree of coverage for the cancellation liability, the credibility in cost estimating, competition at the prime and subcontractor levels, and industry's concerns with high risk, high cost of capital, profits, and strained cash flow. The major players are OMB, the acquisition and financial communities of DOD, industry, and, of course, the congressional appropriations committees by virtue of their tight oversight of the DOD systems acquisition process. We will briefly consider each of the issues in the following sections.

Government Liability Exposure

The criteria for selecting candidate production programs for multiyear procurement were described by the Deputy Secretary of Defense in his May 1, 1981, policy memorandum.[7] They consist essentially of a benefit/risk analysis weighing the benefits to the government, usually in the form of cost avoidance (either in terms of dollars or as a percentage of total cost), against five risk factors: The first is associated with the degree of confidence in the cost-avoidance estimate itself; the second is associated with the degree of confidence in the contractor's capability; and the remaining three relate to the anticipated program stability on the government side, *viz.*, stability of requirements, stability of funding, and stability of configuration. A complete description of these selection criteria is given in Appendix D.

The major point here is that in the majority of cases the basic reason for selecting a stable production program for multiyear procurement is cost savings. Most of these savings arise from the first-year contractual obligations for long lead time items and economic-order-quantity (EOQ) purchases of components, parts, and materials. This often creates a substantial cancellation liability. And the question is, what percentage of the government's obligation must be covered by obligation authority?

The congressional appropriations committees, OMB, and the DOD financial communities favor a full-funding policy. The congressional attitude stems primarily from a reluctance on the part of each Congress to create unfunded liabilities that have the effect of tying the hands of future Congresses and administrations by committing them to either appropriating money for large cancellation charges required to end some of those programs, or continuing the

7. Carlucci, 1 May 1981.

funding of programs they might otherwise not want. Another factor contributing to congressional preference for full funding has to do with oversight. In the last decade or so the Armed Services and Appropriation Committees of both houses have acquired very tight control over weapons systems acquisition. There is congressional concern that relaxation of the full-funding policy would lead to reduced cost visibility and hence to a weakening of congressional control or oversight.

The basic objection of OMB and the DOD financial communities to relaxing the full-funding policy stems from concern that a practice of obligating funds that are not available at obligation time will in some cases ultimately lead to violations of the Antideficiency Act.

There is also the underlying concern here that MYP, in conjunction with a relaxation of the full-funding policy, would reduce the flexibility of both Congress and the Secretary of Defense in responding to unforeseen changes in threat, as well as to breakthroughs in technology, by "locking in" large portions of the defense budget based on decisions made in previous years by previous Congresses and administrations. Stated differently, there is an underlying concern that with relaxation of the full-funding policy, MYP would develop a momentum of its own, because the financial and political pressures to continue the programs would be so high as to inhibit any significant numbers of cancellations even when such actions would be in the national interest. A service proposing a cancellation would first have to go through a rigorous justification showing that the requirement no longer exists, and it would then have to identify the resources for implementing the cancellation. No matter how justified such a decision might be, it is likely to evoke in the news media unpleasant allegations of waste and abuse. The threat of such allegations, coupled with a strong lobbying effort to be expected from the contractor, is likely to act as a strong inhibitor to any cancellation.

Incompatibility of Full Funding with MYP

The basic difficulty with the full-funding policy is that it is fundamentally incompatible with widespread implementation of multiyear procurement in major weapon systems acquisition. As discussed earlier, most of the savings in MYP arise from first-year contractual obligations on long lead time items and economic-order-quantity purchases. Fully funding these obligations creates such a large bulge in the front end of the funding profile that jeopardizes other programs in the budget. The DOD acquisition community regards the full-funding policy as presenting an unnecessary front-end budgeting bow wave that needlessly ties up TOA, in view of the fact that, historically, the probability of implementing cancellations is extremely small. Specifically, they consider the additional TOA provided by OSD for multiyear procurement in the FY 83 budget submission as being at the expense of their other valid requirements. They argue

that continued attempts by Congress, OMB, and the DOD financial communities to force-fit full-funding policies on multiyear procurement will result in a nullification of the opportunities provided in this area by the 1982 DOD Authorization Act, and that MYP of major weapons systems will then revert back to the dormant state in which it existed for almost a decade until the passage of that Act.

The DOD acquisition community is urging the adoption of alternatives to full funding in MYP—for example, incremental funding, funding to termination liability, or partially funding cancellation liabilities by providing a pool of money to cover part of the total cancellation ceilings (including recurring costs) of a group of programs, with the magnitude of the coverage based on a realistic determination of the cancellation probabilities of the programs.

Subcontractors

The decline of the U.S. defense industrial base is particularly severe at the subcontractor level. Multiyear procurement is a potentially powerful force for reversing the decline and should be even more effective at the subcontractor level than at the prime. This is so because even unstable (and therefore high-risk from the MYP point of view) programs may have stable (and therefore low-risk) subsystems to which MYP may be applied. The methodology must, of course, be worked out for such a flowdown to take place. The government should also ensure that whatever benefits are eventually adopted for industry to facilitate MYP—such as higher and more frequent progress payments—are passed along to the subcontractor levels.

Competition

There is virtually unanimous agreement that wider use of multiyear procurement would enhance competition in that firms that may not be interested in bidding on contracts for a single year's requirement might be willing, or even eager, to compete for a contract reflecting, for example, 3 years' requirements. Such situations, although likely to exist at all levels, would probably be more prevalent at the subcontractor levels. Wider interest on the part of industry would contribute toward strengthening the industrial base and driving down prices for the government.

But there is also some concern that wide use of multiyear procurement may ultimately somewhat inhibit competition. This may happen because, under MYP, the government would be locking programs into a few contractors for a relatively long period of time. During this time, the competitive positions of these contractors would be continually enhanced by virtue of their intense activity, while the positions of their competitors would be eroded by virtue of their relative inactivity, to the extent that competitors may be unable to successfully compete for follow-on contracts. This inhibitor could operate with equal intensity at all con-

tractor levels. Thus, wide use of MYP, which holds out the promise of enhancing competition, strengthening the industrial base, and driving down prices for the government, may indeed accomplish these goals initially, but may ultimately lead to some reduction in competition.

The solution to this problem lies in the development of methodologies for tailoring the duration and provisions of MYP to the specific characteristics of various industries so as to enable us to reap the enormous benefits of MYP without incurring its potential disadvantages.

Industry's Concerns

Production contracts are usually of the firm-fixed-price type, and in weapons systems acquisition they are frequently firm-fixed-price with economic price adjustment (EPA). As we have seen before, even a single-year contract, that is, a contract for a single year's requirements, can easily span several years. Hence, in an environment of high inflation, unstable market conditions, changing requirements, and rapidly changing technology, even a single-year production contract holds significant risks for the contractor. In a multiyear production contract, which usually spans a much longer period of time, the risk is multiplied considerably. Industry's major concerns with MYP revolve around excessive risk, cancellation, high cost of capital, and strained cash flow.

Industry claims that the present EPA clauses are inadequate for the relatively long time spans associated with MYP.[8] They advocate the adoption of a formula under which the government would provide at least some coverage of the risks that are clearly beyond the contractor's control, but over which the government can or does exercise some control. Examples cited most frequently by industry are (1) changes in federal and state tax laws, (2) changes in federal and state environmental control laws and regulations, (3) late and/or deficient government-furnished equipment (GFE), and (4) embargoes. Furthermore, to the extent that the contractor assumes increased financial risk under MYP, industry advocates special "profit factor" considerations commensurate with that additional risk.

Industry also advocates inclusion of "opportunity cost or lost profit" in the cancellation ceiling coverage.[9] But since such factors are very difficult to measure objectively, it is highly unlikely that they would ever be covered.

Multiyear contracts usually involve high capital investments during the early part of the contract, which, under the very high interest rates prevailing in recent years, frequently create cash-flow problems for the contractor. Industry would therefore like to see imputed interest on working capital made an allowable cost. Realizing that this is unlikely to happen in the foreseeable future, industry is advocating the development of a formula for increasing the magnitude and fre-

8. Report of the American Defense Preparedness Association (ADPA) Seminar, "Use of Multiyear Concepts in Defense Acquisition," 29 May 1981.
9. *Ibid.*

quency of progress payments as well as payments for out-year requirements.[10] DOD has already initiated action in this area. (See paper by Dr. A. P. Mosier elsewhere in this issue.)

Industry is also advocating relaxation of the DAR level-pricing provision requiring that the government be charged the same unit price over the duration of the production contract.[11] This provision contributes to a situation where the contractor is undercompensated in the early years of the contract and overcompensated in the later years, frequently creating cash-flow strains even in single-year contracts, owing to the very high prevailing interest rates and the fact that interest is not an allowable expense under the DAR. These strains are significantly increased in multiyear contracts because of the longer duration and higher up-front investments.

In spite of the potential advantages of MYP to both industry and government, and in spite of the fact that industry has been strongly advocating expanded use of MYP in weapons systems acquisition, industry appears to be approaching the implementation of MYP with caution. At a recent American Defense Preparedness Association (ADPA) symposium, industry leaders expressed the view that management discipline and prudent applications of multiyear to a few well-chosen programs must be achieved in order to establish a track record of success upon which to justify further expansion in the use of multiyear.[12]

Summary

A great deal of progress has already been made in multiyear procurement: Congress has eliminated the statutory cancellation ceiling limitation and replaced it with a $100 million ceiling reporting threshold. New legislation also gives DOD the authority to include both recurring and non-recurring costs in the cancellation ceiling. Three major programs—the first major programs in almost a decade—were approved for multiyear in FY 1982, carrying an estimated savings of $325 million over single-year procurement. Funding has been included in the FY 1983 budget request for 14 additional MYP programs. And the executive branch has initiated an extensive revision of the pertinent procurement regulations. But we are still far from having a framework that would permit the widespread use of MYP.

The most important single criterion for selecting potentially stable production programs for MYP is anticipated cost savings.

The congressional appropriations committees and the DOD financial community would like to see MYP achieved under a full-funding policy, primarily because of their concern that alternative funding methods may lead to a situation where MYP develops a momentum of its own, resulting in a loss of flexibility on

10. *Ibid.*
11. *Ibid.*
12. *Ibid.*

the part of both Congress and the Secretary of Defense to respond to unforeseen changes in threat and technology. The DOD acquisition community, on the other hand, argues that full funding is inherently incompatible with widespread implementation of MYP because it creates such a large bulge in the front-end funding profile as to jeopardize other programs in the budget. They argue that attempts to force fit a full-funding policy on MYP will lead to its demise. A formula must be found for reconciling the views of these two communities. Such a formula is likely to contain more accurate methods for identifying stable programs, more reliable techniques for estimating the potential cost savings under MYP, and some mechanism for partially funding cancellation liabilities associated with long lead time items and EOQ purchases.

Although there is virtually unanimous agreement that wide use of multiyear procurement would initially enhance competition, both at the prime and subcontractor levels, there is some concern that it may ultimately somewhat inhibit competition by locking programs into a few contractors for relatively long periods of time. A solution to this difficulty lies in the development of methodologies for tailoring the duration and provisions of MYP to the specific characteristics of various industries.

Industry advocates the adoption of broader EPA clauses under which the government would provide at least some coverage for the risks that are clearly beyond the contractor's control, but over which the government does exercise some control, e.g., changes in tax laws. Industry leaders also feel that for multiyear to work, the government must develop some formula for easing the cash-flow problems unique to MYP. ||

APPENDIX A
Definitions

The following definitions of multiyear procurement terms were promulgated by the Deputy Secretary of Defense in his May 1, 1981, policy memorandum on MYP. The Secretary noted that "the definitions may vary from currently accepted uses of the terms to conform to the new policies and procedures."

Advance Procurement. An exception to the full-funding policy which allows procurement of long lead-time items (advanced long-lead procurement) or economic order quantities of items (advance EOQ procurement) in a fiscal year in advance of that in which the related end item is to be acquired. Advance procurements may include materials, parts, and components as well as costs associated with the further processing of those materials, parts and components.

Annual Funding. The current congressional practice of limiting authorizations and appropriations to one fiscal year at a time. The term should not be confused with 2-year or 3-year funds which permit the executive branch more than 1 year to obligate the funds.

Block Buy. Buying more than 1 year's requirement under a single year's contract. A total quantity is contracted for in the first contract year. Block buys may be funded to the termination liability or fully funded.

Cancellation. A term unique to multiyear contracts. The unilateral right of the government not to continue contract performance for subsequent fiscal years' requirements. Cancellation is effective only upon the failure of the government to fund successive FY requirements under the contract. It is not the same as termination.

Cancellation Ceiling. Upon cancellation, the maximum amount that the government will pay the contractor which the contractor would have recovered as a part of the unit price, had the contract been completed. The amount which is actually paid to the contractor upon settlement for unrecovered costs (which can only be equal to or less than the ceiling) is referred to as the cancellation charge. Currently this ceiling includes only non-recurring costs.

Full Funding. Funds are available at the time of award to cover the total estimated cost to deliver a given quantity of complete, militarily usable end items or services. Under current policy (DOD Directive 7200.4), the entire funding needs of the fiscal year production quantity must be provided unless an exception for advance procurement has been approved. A test of full funding is to ask the question, Does any part of this year's buy depend on a future year appropriation to result in the delivery of complete units? If the answer is yes, the contract is probably not fully funded. The principle of full funding applies only to the Procurement Title of the annual appropriation act and therefore affects production contracts but not RDT&E contracts.

Incremental Funding. Funds are not available at the time of contract award to complete a fiscal year's quantity of end items in a finished, military usable form. Future year appropriations are required in order to complete the items or tasks. Incremental funding is commonly used for RDT&E programs.

Multiyear Contract. A contract covering more than 1 year's but not in excess of 5 years' requirements. Total contract quantities and annual quantities are planned for a particular level and type of funding as displayed in the current FYDP. Each program year is annually budgeted and funded and, at the time of award, funds need only to have been appropriated for the first year. The contractor is protected against loss resulting from cancellation by contract provisions which allow reimbursement of costs included in the cancellation ceiling.

Multiyear Funding. A congressional authorization and appropriation covering more than one fiscal year. The term should not be confused with 2-year or 3-year funds which cover only a one fiscal year's requirement but permit the executive branch more than 1 year to obligate the funds.

Multiyear Procurement. A generic term describing situations in which the government contracts, to some degree, for more than the current-year requirement. Examples include multiyear contracts, block buys, and advance EOQ procurement. Generally, advance long-lead procurements in support of a single year's requirement would not be considered a multiyear procurement.

Non-recurring Costs. Those production costs which are generally incurred on a one-time basis include such costs as plant or equipment relocation, plant rearrangement, special tooling and special test equipment, preproduction engineering, initial spoilage and rework, and specialized work-force training.

Recurring Costs. Production costs that vary with the quantity being produced such as labor and materials.

Termination for Convenience. Procedure which any apply to any government contract, including multiyear contracts. As contrasted with cancellation, termination can be effected at any time during the life of the contract (cancellation is commonly effected between fiscal years) and can be for the total quantity or a partial quantity (whereas cancellation must be for all subsequent fiscal year's quantities).

Termination Liability. The maximum cost the government would incur if a contract is terminated. In the case of a multiyear contract terminated before completion of the current fiscal year's deliveries, termination liability would include an amount for both current-year termination charges and out-year cancellation charges.

Termination Liability Funding. Obligating sufficient contract funds to cover the contractor's expenditures plus termination liability but not the total cost of the completed end items.

APPENDIX B
Examples of Relatively Recent Multiyear Procurement

PROGRAM	CONTRACTOR(S)	MULTIYEAR QUANTITY	FY COVERED	APPROX. CONTRACT VALUE ($ M)	ESTIMATED SAVINGS ($ M)	POC FOR FURTHER INFO
F-16 Aircraft	General Dynamics	480	82-85	3,000	350	Capt G. Polesky Mr. C. Holloman AV 785-6853 (513) 255-4746
AN/ TRC-170 Radio	Raytheon	110	82-84	220	18.7	MAJ C. Rogano 694-4600 LTC V. Fields LTC T. Kilpinski AV 478-5980
GAU-8* 30 mm Ammunition	Aerojet Honeywell	25.2 million	80-82	329	33.9	Capt D. Riediger Mr. R. Shaw (301) 981-4906 (301) 981-6273

*Classical MYP

APPENDIX C
MYP Programs Included in DOD FY 1983 Budget*
($ in millions)

	FY 1983 TOA INCREASE	NET 5-YEAR SAVINGS
F-111 Weapon Navigation Computer	—	9.9
C-2 Aircraft	32.4	58.4
SM-1 Missiles	48.1	62.7
EA-6B Aircraft	9.1	21.1
A-6E Aircraft	5.0	20.3
NATO Seasparrow Launcher	9.0	37.2
MULE Laser Designators	10.5	5.5
T-AO Fleet Oilers	109.8	66.5
MK-46 Torpedoes	34.5	40.4
CH-53E Helicopters	29.9	35.0
DMSP Satellites	30.7	49.3
NAVSTAR GPS Systems	—	249.3
MLRS Rocket Systems	53.2	64.0
Black Hawk Helicopters	159.2	81.1
ALQ-136 Radio Jammers	14.5	14.7
	545.9	815.4

NOTE: Includes only the portion of FY 1983 funds for these systems that was added to initiate multiyear contracts and thus attain the beneficial effects of the "savings" column.

Excludes F-16, and AN/TRC-170 radio programs which were initiated in FY 1982 and should save an additional $264.7 million over the 5-year period.

The "5-year savings" amount represents the savings above and beyond recovery of the FY 1983 investment amount.

*Extracted from testimony by the Deputy Secretary of Defense Frank C. Carlucci before the House Armed Services Committee on the Department of Defense Authorization for Appropriations for FY 1983, February 3, 1982.

APPENDIX D

Criteria for Selecting Multiyear Procurement Candidates (as promulgated by the Deputy Secretary of Defense in his May 1, 1981, policy memorandum on MYP)

The process of deciding to use or not to use a multiyear procurement (MYP) for production programs as well as how best to tailor and structure MYP requires management judgment. The following criteria have been prepared as guidelines for decision-makers. The criteria are to be considered in a comparative benefit/risk analysis format where criterion 1 below represents the benefit factor, and criteria 2 through 6 represent risk factors.

1. Benefit to the Government. A multiyear procurement should yield substantial cost avoidance or other benefits when compared to conventional annual contracting methods. MYP structures with greater risk to the government should demonstrate increased cost avoidance or other benefits over those with lower risk. Savings can be defined as significant either in terms of dollars or percentage of total cost.

2. Stability of Requirement. The minimum need (e.g., inventory or acquisition objective) for the production item or service is expected to remain unchanged or vary only slightly during the contemplated contract period in terms of production rate, fiscal year phasing, and total quantities.

3. Stability of Funding. There should be a reasonable expectation that the program is likely to be funded at the required level throughout the contract period.

4. Stable Configuration. The item should be technically mature, have completed RDT&E (including development testing or equivalent) with relatively few changes in item design anticipated and underlying technology should be stable. This does not mean that changes will not occur but that the estimated cost of such changes is not anticipated to drive total costs beyond the proposed funding profile.

5. Degree of Cost Confidence. There should be a reasonable assurance that cost estimates for both contract costs and anticipated cost avoidance are realistic. Estimates should be based on prior cost history for the same or similar items or proved cost estimating techniques.

6. Degree of Confidence in Contractor Capability. There should be confidence that the potential contractor(s) can perform adequately, both in terms of government furnished items (material, data, etc.) and their firm's capabilities. Potential contractors need not necessarily have previously produced the item.

Contractor Incentives to Improve Reliability and Support

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Dr. John P. Solomond

Historically, procurement incentive programs within the Department of Defense (DOD) have been primarily devoted to enhancing contractor motivation toward improved performance and reduced costs. Secondarily, some program management offices have made efforts to apply incentives to accelerate program schedule. Heretofore, DOD has placed relatively little emphasis on the important consideration of using contractor incentives to improve field reliability and support.

The purpose of this paper is threefold. First, it identifies the shortfall in support and readiness, and shows how the Acquisition Improvement Program addresses the readiness problem. Second, the paper examines the use of incentives to motivate contractor performance in the area of field reliability and support. Third, it contains a discussion of five weapon systems and the concomitant DOD programs that utilized warranties or incentive contracting techniques, *viz.*, the Army Firefinder system (AN/TPQ-37), the Black Hawk T-700 engine, the Air Force F-16 aircraft, the Air Force/Navy advanced medium range air-to-air missile (AMRAAM), and the Navy F/A-18 aircraft. These successful programs illustrate some of the ongoing activity that the services have undertaken in using incentives to improve reliability and support.

The only one of the above programs that lacks measurable data for verification of the results is AMRAAM, and work on this system was done prior to the publication of the DOD Acquisition Improvement Program. Still, the AMRAAM program serves to illustrate the spirit and intent of the new administration's defense acquisition policy. Specifically, the Air Force and the Navy considered four techniques for AMRAAM: a reliability incentive fee, an availability guarantee, a type of verification guarantee, and a reliability improvement warranty, which exemplify potential application of the prospective policy. Thus, AMRAAM, as well as the other weapon systems, represents precedents from which we may gain insight into the use of incentive programs to promote readiness.

Support and Readiness Shortfalls

There is a concern at all levels about U.S. military readiness. This concern stems, in part, from the heavy emphasis placed by the services on performance, often to the detriment of reliability and maintainability. However, prompted by expressed administration policies, DOD has gradually accentuated the issue of supportability since the early 1970s, thus requiring the services to reassess their

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priorities. This evaluation culminated in the April 1981 memorandum, which stated, as a fundamental management principle, that supportability is to be considered equivalent in priority with performance, cost, and schedule.[1]

According to a recent report published by the Readiness Panel of the House Armed Sevices Committee, readiness is defined as "A balancing of manpower, investment, and operations and maintenance expenditures that produces a force structure capable of a rapid, sustained, and ultimately successful response to the threat."[2]

The Readiness Panel examined the interrelationship of operation and maintenance (O&M) accounts and other DOD accounts and found no formal or institutionalized system to ensure that personnel and procurement initiatives sponsored by the Congress have complementary O&M appropriation increases. They identified two major phenomena that have exacerbated existing readiness deficiencies: The first is an increase in the overall defense budget. This has led to a relative reduction in the operation and maintenance accounts. Second is an increase in weapon systems procurement without regard to budgetary requirements for a logistics or support "tail."

This institutional shortfall in funding illustrates the importance of providing effective contractor incentives to improve field reliability and support within the budgetary constraints. These incentives can be financial motivators, or mandatory source-selection criteria, which focus attention on field reliability and support.

DOD Acquisition Improvement Program

In March 1981, five working groups within the Department of Defense undertook a 30-day examination of the defense acquisition process, coordinated their findings during March 1981, and forwarded their recommendations to Deputy Secretary of Defense Frank C. Carlucci. The Deputy Secretary approved 23 specific recommendations and eight general issues identified by these groups, and issued a memorandum dated April 30, 1981, outlining fundamental principles of acquisition management that were to be followed by the services. Later, in July 1981, a 32nd "action" or initiative, dealing with competiton, was added to the package.

One of the aforementioned five DOD acquisition improvement working groups convened particularly to examine shortfalls in the DOD acquisition process related to readiness. Among the recommendations of this working group was one to examine more closely contractor incentives to improve field reliability and

1. "Improving the Acquisition Process," memorandum from the Deputy Secretary of Defense, April 30, 1981.
2. "Review of Readiness Considerations in the Development of the Defense Budget," Report of the Readiness Panel of the Procurement and Military Nuclear Subcommittee of the House Armed Services Committee, Ninety-Sixth Congress, December 31, 1980.

support. These incentives are described as "contractor incentives" vs. "contract incentives." Unlike the latter, which are limited to financial motivation, contractor incentives include mandatory source-selection criteria. The group suggested that reliability, maintainability, operational availability, and supportability be elevated to the status theretofore held by cost, schedule, and performance. This was not to diminish the importance of these latter criteria, but only to establish the necessity of attention to the support disciplines, i.e., logistics, reliability, maintainability, and quality assurance, in order to enhance the overall operational suitability of a fielded system.

Action 16—Contractor Incentives to Improve Reliability and Support

Among the actions approved by Mr. Carlucci on April 30, 1981, was Action 16, "Contractor Incentives to Improve Reliability and Support," which mandated that acquisition strategies include incentive programs, unless impracticable. These programs were to be designed to encourage contractors to attain the DOD's new reliability and maintainability goals, among which are a reduction in the maintenance manpower required, and a lowering of the skill levels necessary to operate and service the weapon system.

The "acquisition strategy" is a composite of the broad concepts that will direct and control the overall acquisition process. The "acquisition plan" expands upon the strategy to formally document those definitive actions that must be accomplished at various phases of the acquisition cycle. The Deputy Secretary of Defense recommended that the acquisition strategies identify the approaches and techniques to apply incentives to contracting in order to attain necessary levels of reliability and maintainabilty. The acquisition plan, on the other hand, should document those fundamental engineering design disciplines necessary to ensure the development of a system sufficiently reliable to meet the threat. If such documentation is provided, it generally appears as an appendix to the acquisition plan, especially in military weapon systems developed for the Navy.

The acquisition strategy should also include the approach to be taken in the request for proposal (RFP) evaluation, as well as the description of specific financial rewards, such as award fees, incentives and guarantees, for improving reliability. Implicit in the Deputy Secretary's mandate was the expansion of the use of award fees and reliability improvement warranties as vehicles to improve field reliability and support. As previously mentioned, there are already some programs within the DOD that have had favorable results in implementing incentive contracting techniques. These will be examined in detail later.

During the summer of 1981, the Deputy Secretary of Defense requested that the Under Secretary of Defense for Research and Engineering (USDRE) develop a set of guidelines for implementing the initiative on incentives. In response, the USDRE issued a memorandum dated August 26, 1981, which specified that "each component (military service) shall identify selected acquisitions using the various

types of incentive arrangements, gather factual material and evaluate the experience that has been gained using incentives, including contractor comments."[3] Each service was to develop a list of roughly five candidate programs that would be appropriate for incentive contracting in the field reliability and support area. In addition to requiring a list of candidate systems, the memorandum emphasized the importance of generating souce-selection evaluation criteria for reliability and maintainability, specifically including manpower, support, and deployment objectives. The criteria should provide guidelines to bidders relating to the design and engineering aspects that are critical to the reliability, readiness, and manpower objectives for the system. The relative importance of the readiness and support factors in the source-selection evaluation criteria should reflect the new DOD emphasis on these areas and the traditional consideration of the operational value of the items being procured. The role of these criteria in the selection process should be explained and their significance stressed in the request for proposal (RFP) and during the debriefing of unsuccessful offerors.

The USDRE August memorandum further stated that contract clauses used to implement the incentive portions of the contract may be based either on measures of contractor performance, e.g., an award fee based on the contractor's successful effort on a design or analysis task, or on measures of product performance, e.g., a contract incentive based upon demonstrated product reliability. When production contracts include product performance agreements for system reliability, maintainability, or support, the government should insist on adequate system performance under realistic field operating conditions prior to accepting the equipment.

In addition, the memorandum stated that the results of the incentive program should be captured, evaluated, and disseminated. The Air Force has taken the initiative in this respect with the publication of a Product Performance Agreement Guide, which contains a summary of various incentive contracting techniques.[4] It also describes the proper application and use of warranty contracts in Air Force procurement, and surveys four basic types of product performance agreements:

—Provisions of the defense acquisition regulation (DAR);

—Provisions involving extensive contractor repair responsibility and intermediate or depot level;

—Provisions that require field measurements of operational systems to determine compliance with product performance requirements;

—Provisions containing specific features outside of those categorized above.

In addition, the Air Force is endeavoring to establish a Product Performance Agreement Center (PPAC) at Wright-Patterson AFB, Ohio, to promote the wider

3. "Contractor Incentives to Improve Reliability and Support," memorandum from the Under Secretary of Defense for Research and Engineering, August 26, 1981.

4. "Product Performance Agreement Guide," joint publication of the Air Force Logistics Command, and the Air Force Systems Command, August 18, 1980.

use of product performance incentives, to facilitate the feedback of previous results into current applications, and to publish new incentive approaches. It is anticipated that the facilities and information of the center will be available to both DOD and industry personnel. The center will be a clearing house for information on product performance agreement applications, and will provide analyses on and summaries of the use of such incentives, the results obtained, and lessons learned. Finally, PPAC personnel, on request, will provide technical support to Air Force program offices and contractors in selecting, planning, contracting for, and administering specific program arrangements.

Further information concerning the PPAC may be obtained from the Director, Systems and Support Contracts, HQ Air Force Systems Command, Andrews AFB, Md. 20334, 301-981-6433 or Autovon 858-6433.

In the area of manpower and logistics support improvements, approaches are being developed to improve the capability to translate maintenance manpower skill projection into design or program requirements. These activities include:

—A joint effort between the services and the Office of Manpower Reserve Affairs and Logistics (MRA&L) to develop front-end logistic support analysis guidelines to identify early initial support candidates that can be incentivized;

—Approaches to identify skilled manpower and training requirements (MRA&L responsibility);

—Strategies to solve the skilled maintenance manpower problem for high performance systems by using contractor support in the mid-term, and designing away complexity in the longer term.

The specific implementation of Action 16 will require action from the Office of the Secretary of Defense (OSD) and each of the services. To accomplish this goal, the service material commands will establish a senior-level group of personnel from the procurement, readiness support, and reliability disciplines to select and establish the implementation approach on each weapon system, e.g., award fees, incentives, or source-selection criteria. The Under Secretary of Defense for Research and Engineering (Acquisition Management) will review acquisition strategies for adequate funding for incentives, and for approaches to applying incentives to support and readiness. Also, highly visible reliability and support thresholds will be established and demonstrated via test and evaluation prior to a production decision. Finally, the DOD directive on use of contractor and DOD resources for maintenance of materiel (DODD 4151.1) will be revised to encourage wider application of contractor support for indirect (field level) maintenance, using appropriate contract incentives particularly in the areas of reliability and maintainability, and for overcoming shortfalls in military service skilled maintenance personnel if the contractor's personnel will be available for wartime support in a combat zone. The revision of DOD Directive 4151.1 by MRA&L will be issued by mid-summer 1982.

Use of Source Selection Criteria

A clear delineation of source-selection evaluation criteria is necessary to assure that the contract awarded contemplates a truly reliable and maintainable design. There are basically two approaches to maximizing the above-mentioned objectives. One is for the contracting officer to allow the contractor flexibilty in tailoring an assurance program for the specific application of broad reliability and maintainability requirements, and then to verify the conformance thereto by demonstration tests. In the second approach, the contractor is given very little flexibility in his design approach. The government participates heavily in the entire design process, specifying derating criteria and dictating design analyses such as stress analysis, failure mode effects and criticality analysis (FMECA), and reliability predictions, which detailed requirements for each.

Using the first approach, the government allows the contractor freedom to experiment with alternative engineering design approaches relative to field reliability and support. Any intervention by the government only serves to diminish the responsibility assumed by the contractor to create a design that is superior from the standpoint of reliability and support. In the second approach, the government specifies the design technique and methodology. Although this approach reduces the individual creative input of the contractor, it does increase the possibility of utilizing alternative sources, because the contractor's responsibility in the production process is limited to compliance with explicit government specifications.

The source-selection process can be used to develop a hybrid of these two extreme approaches by giving the contractor flexibility in responding to the RFP and then making his proposed approach a contractual requirement when the contract is awarded, thus allowing the government to capitalize on the contractor's engineering talents and experience in proposing innovative design approaches, while at the same time imposing proved reliability design disciplines. This more moderate approach also would provide the government with the opportunity to judge the contractor's depth of understanding of the reliability design discipline.

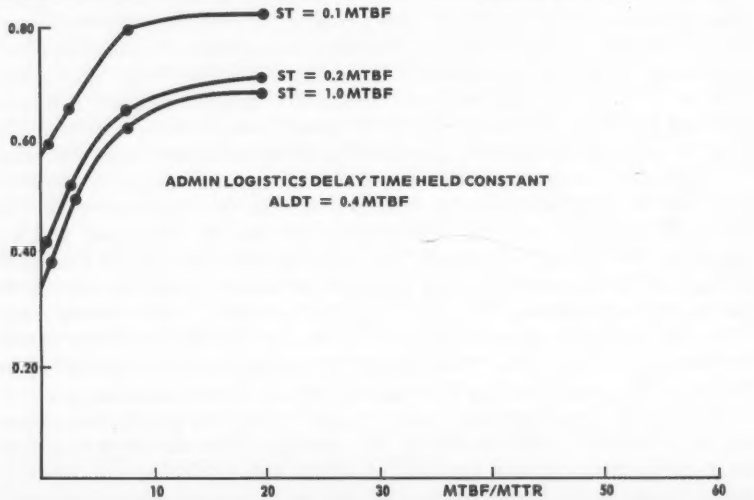
The relative weighting of RFP evaluation criteria and equipment specifications must be modified somewhat to successfully use the hybrid approach. The RFP must emphasize that the specification provides the minimum, and not necessarily the desired, requirement, and must clearly state that the contractor can increase his score by proposing a design that not only meets, but *exceeds* the specification requirements. This encourages the contractor to perform cost tradeoff studies during the proposal stage so that he can maximize his scores in both the technical and cost areas. Traditionally, the contractor would have proposed the system design with the best cost that would meet the minimum requirements.

In using the latter approach, care is needed to preclude placing unnecessary design constraints on the contractor. For example, if the service is concerned about maintaining a certain threshold on operational availability (A_o), the contractor should be left free to propose the best set of requirements on mean time

between failure (MTBF) and on mean time to repair (MTTR) which, from a life-cycle cost and readiness viewpoint, meets the threshold on operational availability. By specifying the required levels of MTBF and MTTR explicitly, the service would limit the possible improvements in operational availability made by simultaneously varying MTBF, MTTR, standby time, and administrative logistics delay time. The detrimental effect of such a narrow method of evaluation is apparent from Figure 1, which shows that operational availability is a function of standby time (as well as of administrative logistics delay time, MTBF, and MTTR).

Another related phenomenon occurs when the level of spares provisioning is inversely proportional to the system's MTBF. Under this circumstance, systems with higher inherent reliability as measured by the point estimate on reliability, i.e., MTBF, could experience lower operational availability at some point within the system's operating time horizon. This would occur because the spares provisioning level is calculated independently from the administrative logistics delay time. Consequently, when the spares inventory kept by the service is depleted, requests for spares could not be satisfied. Thus, the equipment requiring the spare would have to remain in a failed state until an additional supply source could

FIGURE 1
Operational Availability vs. Ratio of MTBF to MTTR



provide one. Hence, this phenomenon reduces the operational availability of the end item.

Next, I will discuss a particular contractual mechanism for improving an equipment's field reliability, the reliability improvement warranty (RIW).

Reliability Improvement Warranty

Specific warranty contracts can serve to motivate the contractor to improve reliability and support. One of the most commonly used provisions is the reliability improvement warranty (RIW), which is a fixed-price contractual provision that involves incentives for reliability and maintainability achievement through a commitment for contractor repair of all covered failures. The price of the reliability improvement warranty is negotiated based on the projection of field reliability (measured by the MTBF), together with a projection of average repair costs. Thus, the contractor can achieve a higher profit by developing a system that exhibits a higher field reliability, expressed in MTBF. A variation of this is the reliability improvement warranty with a combined MTBF guarantee. With this provision the contractor is obligated to provide consignment spares, at no cost to the government, while the failed items are being repaired or replaced.

The concept of a reliability improvement warranty is innovative in the sense that, rather than being indifferent to field experienced failures, the contractor now has a financial incentive to limit the number of field failures because the cost of their repair is taken from the original payment for the warranty contract. Without a warranty, repairs either would be made at a government depot, at the general support level, the direct support level, or by a contractor; all repairs would have been performed at the government's expense.[5]

There are several reasons why a contractor would propose an RIW for a particular contract:

—It is required by the RFP;
—It is potential source of additional profit; or
—It would lead to a competitive advantage in future contract awards.

The first two reasons represent short-term factors, while the last one reflects a long-term consideration. This distinction is important from the standpoint of risk and uncertainty because, in the long-term, the contractor may consider the portion of the contract related to the RIW as investment, which could yield future business profits. The risk, on the other hand, is the potential financial loss to the contractor that could arise if he overestimates the true field-measured reliability, expressed in terms of MTBF. This is illustrated in Figure 2, where the cost of the reliability development program and expected repair costs are plotted, together with the warranty price, as a function of MTBF. Two specific values of MTBF,

5. H. S. Balaban and M. A. Meth, "Contractor Risk Associated with Reliability Improvement Warranty," *Proceedings*, 1978 Annual Reliability and Maintainability Symposium.

θ_1 and θ_2 are critical from the standpoint of contractor profit. Values of field MTBF between θ_1 and θ_2 will yield a net positive profit, while MTBF values either below θ_1 or above θ_2 will result in an expected loss. This is due to the fixed-price provision of the reliability improvement warranty, which imposes both risk and potential financial reward upon the contractor.

For RIW application to have maximum effect, contractors should be told early in development that a warranty is anticipated. It is also desirable to elicit a warranty quote during full-scale development. This allows the contractor to place additional emphasis on design for maintainability.

For a program to be selected for RIW application, there are a number of criteria that should be satisfied. A major criterion is a limitation on the maximum risk that would be faced by both the company and the government. This risk is influenced by several factors:

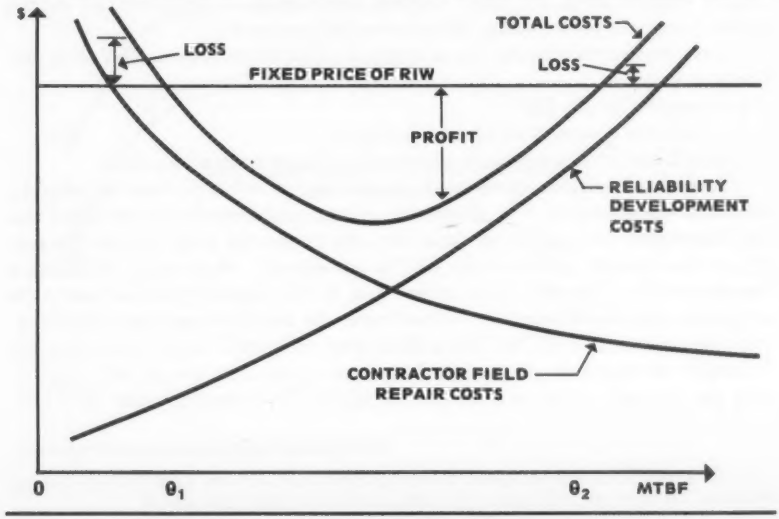
—The technological state of the art of the equipment;

—The availability of test data on which to base cost and reliability estimates; and

—The accurate projections of the anticipated mission, environment and expected utilization.

The more uncertainties there are with respect to the equipment, the more latitude there is in tailoring the provisions of the RIW. In no case, however,

FIGURE 2
Warranty Price and Total Cost as a Function of MTBF



should the terms be tailored to such an extent that the incentives relating to the RIW objective of improved reliability and reduced support costs are diminished.

It should be noted that an RIW is not a maintenance contract, and does not require that the contractor provide routine periodic upkeep, adjusting, cleaning, or other normal upkeep. Likewise, it does not cover those components of a warranted item that are expected to need replacement under normal use during the term of the warranty, such as filters, light bulbs, etc. These items may be provided for by separate provisions in the contract, consistent with current regulations, but they should not be included in the RIW provision. In general, an RIW will provide for the repair or replacement of failed units as well as agreed-to "no cost" engineering changes and the calibration, adjustment, and testing associated therewith. The basic philosophy of the RIW is that during the warranty period, the contractor will have an incentive to improve the reliability and to reduce the repair cost of the equipment through the mechanism of "no-cost" engineering change proposals. Once a fixed price is established for the warranty, the actual profit realized by the contractor is dependent upon the equipment's reliability and maintainability in service use, plus any improvements that he can make in its reliability and maintainability in order to keep the number and cost of repairs as low as possible. Thus, an RIW becomes a contracting technique by which the government derives the benefits of improved reliability and maintainability for each additional dollar that the contractor earns.

Additional Incentive Techniques

Besides using specific source-selection evaluation criteria and warranties, award fees, based on measured values of reliability and maintainability under test conditions similar to field operating conditions, are encouraged. Award-fee contracts are mechanisms for providing bonus payments over and above the initial contract price when specific performance thresholds are exceeded. These thresholds can be point estimates on reliability or maintainability, such as mean time between failure or mean time to repair, or they can be estimates of operational availability. However, because operational availability is dependent upon such parameters as standby time and administrative logistics delay time, operational availability is more difficult to assess. Both the Navy F/A-18 and the Army Firefinder programs incorporated a contractual award fee structure for improving reliability.

Provisions for contractor maintenance during field usage are also feasible under the provisions of Action 16. These provisions would permit accurate contractor data collection on support parameters, as well as provide a potential source of revenue for the contractor.

Examples of Incentive Contracts

Let's look now at some examples of the use of incentive contracts and warranty techniques as motivational stimuli for improving reliability and support. In

subsequent paragraphs, five separate systems will be discussed. The first is the Army's Firefinder system (AN/TPQ-37); in this program the contract provides for a specific incentive payment associated with particular point estimates of time between failure, i.e., MTBF. The Army's T-700 engine program, on the other hand, utilized a reliability improvement warranty; the reliability results achieved were beyond expectation. The Air Force F-16 program also utilized reliability improvement warranties. The warranties were applied to several pieces of avionics equipment and, in two cases, were combined with MTBF guarantees. The F-16 case is particularly worthy of note because the RIW and RIW/MTBF guarantee contracts were let with subcontractors responsible for the avionics end items. In contrast, however, the joint Air Force/Navy Advanced Medium Range Air-to-Air Missile (AMRAAM) did not use RIWs because of the low operational utilization during the initial production phases; instead, this program used a series of more conventional contractual incentives to achieve the desired level of reliability. The Navy used conventional award-fee contractual techniques on its F/A-18 program; however, the Navy added a unique combination of engineering analysis and dedicated reliability test items. As a consequence, it effectively met its mature-system reliability goal after only 2,500 hours of flight testing.

ARMY FIREFINDER SYSTEM (AN/TPQ-37)

Initially, this program had virtually no requirements for reliability, availability, or maintainability placed on the contractor. There were goals for MTBF and MTTR, but no formalized program for reliability growth, environmental testing, failure analysis, or incentives. Firefinder was a major Army system with a unit cost goal of $1.5 million (1973 dollars), and had an expected production buy of 115 systems.[6]

The approach to developing a reliability program was a two-phase effort and included a short-range effort for advanced development, and a long-range effort for limited production. The incentive contracting was associated with the long-term effort during limited production. The incentive program for reliability provided specific dollar amounts for each level of reliability demonstrated above the minimum acceptable. Table I contains a tabular listing of the incentive payments associated with the reliability performance of the AN/TPQ-37.

ARMY T-700 ENGINE

The Army's Black Hawk program incorporated a warranty on its T-700 engine, manufactured by General Electric.[7] Other dynamic components also had warranties, but the T-700 is especially noteworthy as a success story. The T-700 engine warranty provided for both a contractor and government data collection

6. A. R. D'Angelo, "A Reliability 'Catch-Up' Program that Worked: Firefinder, a Case History," *Proceedings*, 1982 Annual Reliability and Maintainability Symposium.

7. Major Richard R. Walker, USA, "T-700 Warranty-Insurance or Charity," Report 2520-81, Air Command and Staff College.

TABLE I
Failures in 1500 Hours

FAILURES IN 1500 HOURS	MTBF (HRS)	$ INCENTIVE
12 OR FEWER	125.0	565 K
13	115.4	508 K
14	107.1	452 K
15	100.0	396 K
16	93.8	339 K
17	88.2	283 K

system to ensure accurate monitoring of elapsed operating time and the repairs performed. However, this also increased the cost and administrative burden associated with the warranty.

The warranty was a variation of the reliability improvement warranty mentioned earlier. Specifically, the contractor, G.E., agreed to pay parts and labor costs of engines that failed with fewer than 250 operating hours, and would pay a prorated share of the parts costs for engines failing between 250-500 operating hours. The Army would pay for repairs for any engines failing beyond 500 hours. Additionally, an incentive payment was made to the contractor for any part of the engine that operated without failure beyond 500 hours. This constitutes an implicit reliability improvement warranty in the sense that improved reliability was rewarded with a cash payment. The cash-incentive payment amounted to 5 percent of the list price of the part, with a maximum incentive of $931,000 to $1,076,000 depending on the number of aircraft engines produced.

The figures in Table II trace the reliability growth of the T-700 engine from 1974 until October 1981.[8] They basically represent a point estimate of the time

TABLE II
Mean Time Between Removal (MTBR) Requiring Depot Repair for T-700 Engines

	1974-76	1978	OCT. 1981
ALL CAUSES	215 HOURS	201 HOURS	1,471 HRS (835 HRS)[8]
WARRANTY COVERED REMOVALS	419 HOURS	522 HOURS	

SOURCE: REPORT 252081 AIR COMMAND AND STAFF COLLEGE AND CONVERSATIONS WITH PERSONNEL FROM THE BLACK HAWK PROGRAM OFFICE

8. The figure 835 hours for MTBR in October 1981 was based on an assessment using the Weibull density of time between removals, while the point estimate of 1,471 hours was based on a constant failure rate (exponentail density) model.

between removals (repairs) when depot-level repair was required. The figures given for 1974-76 are the contractors estimate of the YT-700 prototype engine performance during contractor and government testing, encompassing some 40,000 hours.

The 1978 data comprise the first 4,200 field operating hours, while the data through October 1981 represent the results of 105,450 cumulative flight hours, or approximately 126,540 engine operating hours, during which 86 chargeable failures occurred. These figures are especially noteworthy, because negotiations were carried out with the expectation that the mean time between removal would only grow to 750 hours. In fact, this was the point for the maximum incentive payment of G.E.

AIR FORCE F-16 PROGRAM

The reliability improvement warranty program associated with the F-16 aircraft procurement represents one of the most ambitious endeavors in military procurement, with nine avionics line-replaceable units (LRUs) being covered by the RIW provisions. The basic strategy of the Air Force was to establish practical controls on reliability and life-cycle cost through the use of the RIW and logistic support cost commitments.[9]

Because life-cycle-cost control was the major objective of the program, it is not surprising that the F-16 extensively utilized the RIW provisions in its avionics procurement. The extent of coverage on the F-16 was 300,000 cumulative flight hours or 48 months of flying, whichever came first.

Table III summarizes the F-16 coverage. Two of the nine LRUs (radar transmitter and HUD electronics) are also covered by an MTBF guarantee that requires the contractor to provide corrective action, as well as additional spares, if units fail to meet the MTBF specified in the contract. The actual number of spare units to be provided was calculated from a formula contained in the RIW contract. If the guaranteed value of MTBF is achieved prior to the final year of the RIW contract, as demonstrated by the results from two consecutive measurement periods, then the contractor is released from any further obligations under the MTBF guarantee. The line-replaceable units will, however, remain under the RIW. This mechanism increases the potential financial risk of the contractor, because these consignment spares are provided at the contractor's expense, so there is an additional incentive to produce equipment with sufficiently high inherent reliability.

AMRAAM

The advanced medium range air-to-air missile (AMRAAM) system is being developed as the new beyond-visual range armament for the F-14, F-15, F-16, and

9. H. Balaban, D. Cuppett, G. Harrison, "The F-16 FIW Program," *Proceedings*, 1979 Annual Reliability and Maintainability Symposium.

F/A-18 aircraft. The AMRAAM employs some innovative management in the areas of independent testing under combined environments, implementation of warranties/incentives, and independent program assessments.[10]

The AMRAAM program initiated a Warranty Incentive Working Group, which examined over 18 approaches to warranties and incentives based on the results experienced on past programs. Only four approaches were considered feasible for AMRAAM:

—A reliability incentive fee;
—An availability guarantee;
—A type of verification guarantee; and
—A reliability improvement warranty

The missile parameters were then matched against these approaches as indicated in Figure 3. The reliability improvement warranty was not selected because of the low operational utilization of AMRAAM in the initial production phases and the anticipated difficulty of administration. There were several incentive programs selected, each of which will be considered in turn.

The captive carry reliability incentive program (CCRIP) utilized the missile "test analyze and fix" and the reliability demonstration test. A significant incentive fee was associated with the reliability demonstration test.

TABLE III
Summary of F-16 RIW Coverage

UNIT	SUBCONTRACTOR	MTBF GUARANTEE	COVERAGE LEVEL
RADAR TRANSMITTER	WESTINGHOUSE	YES	LINE REPLACEABLE UNIT (LRU)
HEAD UP DISPLAY (HUD) ELECTRONICS	MARCONI-ELLIOTT	YES	LRU
RADAR ANTENNA	WESTINGHOUSE	NO	SHOP REPLACEABLE UNIT (SRU)
RADAR LOW POWER RADIO FREQUENCY	WESTINGHOUSE	NO	LRU/SRU
RADAR DISPLAY	WESTINGHOUSE	NO	LRU/SRU
RADAR COMPUTER	WESTINGHOUSE	NO	LRU/SRU
FLIGHT CONTROL COMPUTER	LEAR-SIEGLER	NO	LRU/SRU
NAVIGATION UNIT	SINGER KEARFOTT	NO	LRU/SRU
HEAD UP DISPLAY	MARCONI-ELLIOTT	NO	LRU/SRU

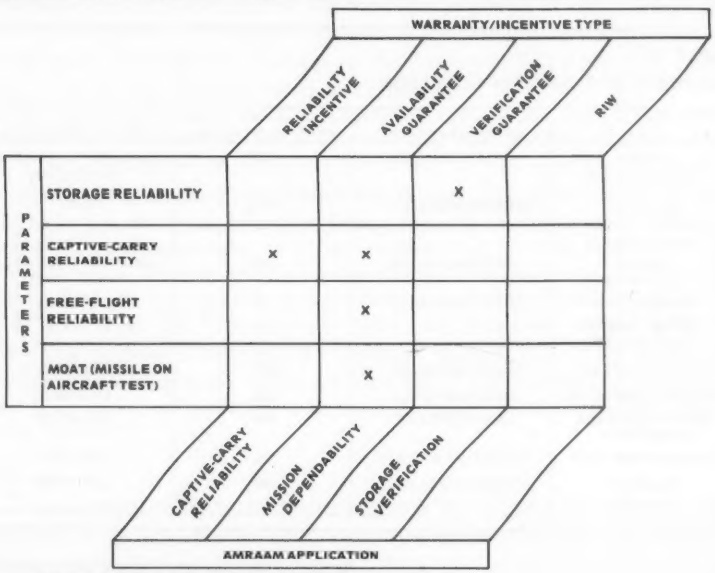
10. Executive Seminar for Product Assurance, AMRAAM Case Study, PA-11, A, B, Defense Systems Management College, December 10–11, 1981.

This was to be the most effective motivational feature in emphasizing captive-carry reliability as an important program parameter during the early phases of full-scale development.

The mission dependability guarantee was a system performance incentive that included the captive carry, and the free-flight positions of the factory-to-target sequence. It also included the missile-on-aircraft test (MOAT). System mission dependability will be calculated using data from the existing operational test programs, and mission dependability will be used as one of the criteria in the AMRAAM award-fee program. An award-fee panel will convene about every 6 months to measure the contractor's progress in achieving mission dependability, cost targets, program milestones, and other acquisition goals.

Storage reliability was the single parameter that required development of a unique test program—the storage verification guarantee (SVG). To obtain data for the SVG, the government will select production missiles at random and store them at operational locations for 2 years. At the end of this period the missiles will be withdrawn from storage, tested, and storage reliability wil be calculated.

FIGURE 3
Applications of Warranties/Incentives to AMRAAM



SOURCE: EXECUTIVE SEMINAR FOR PRODUCT ASSURANCE, AMRAAM CASE STUDY, PA-111A, B, DSMC, 10-11 DEC 81.

A positive incentive will be available for the contractor if storage reliability meets or exceeds the specification minimum; conversely, the contractor will be required to retrofit some portion of the inventory should the SVG results be unsatisfactory. This "reward/punishment" system has already brought a great degree of commitment to the storage problem during the development process.

It is essential to note that the warranty program has not been developed as a substitute for the AMRAAM reliability program. The reliability program was developed under the policies of MIL-STD-785B, and the warranty program was used to identify some key government priorities to the contractor.

NAVY F/A-18 PROGRAM

The Navy F/A-18 Program utilized an award fee to motivate the prime contractor toward the achievement of reliability and maintainability goals. There were three separate award fees associated with the F-18 contract: reliability, $12 million; maintainability, $12 million; and life-cycle cost and program schedule, $15 million. Thus, of the total award fee of $39 million, the reliability and maintainability portion was $24 million, or 61 percent of the total award.[11]

The reliability award fee was divided into two portions. A $4 million award fee after 1,200 hours of flight testing, and an $8 million award fee after 50 flights. Both award fees are based on point estimates of reliability as measured by the calculation of mean flight hours between failure (MFHBF). The $12 million award fee on maintainability was based upon three distinct measurements:

—A calculation of unscheduled maintenance man-hours per flight hours at the organizational level;

—A calculation of maintenance man-hours per flight hour for the weapon system; and

—A calculation of the mean flight hours between maintenance action.

The award fee for maintainability was divided equally at $4 million for each category.

Figure 4 contains a summary of the F-18 award fee, together with the chronological payment schedule.

This award-fee incentive was supplemented, as well, by dedicated subcontractor reliability development testing. Table IV contains a partial list of end items that had dedicated reliability development tests. Of those end items sampled, almost 10 percent were specifically purchased for reliability development testing. This list is not complete, but only serves to illustrate the emphasis placed on achieving reliability during the development of the F/A-18.

As of November 1980, the Navy's estimate of F/A-18 reliability expressed in mean flight hours between failure was 1.9 hours, based on the first 1,200 hours of flight testing. Also, there has been significant visibility of subsystem problems

11. DOD Product Engineering Services Office memorandum, MRA&L, Subject; F/A-18 Reliability, February 28, 1981.

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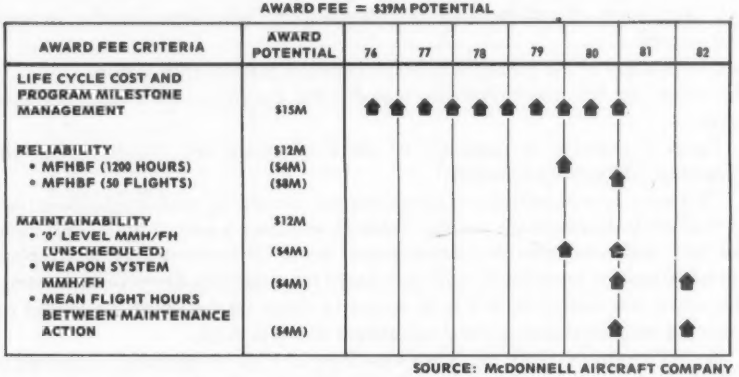
together with corrective actions required to rectify the problems. These corrective actions have resulted in a demonstrated reliability of 2.38 MBHBF after, 2,500 hours of flight testing, which exceeded the goal of 1.4 hours (expected after 2,500 hours of flight testing). These quantitative measures are illustrated in the bar chart of Figure 5.

Conclusions

The goals specified in both the April 1981 memorandum, and the August 1981 memorandum are worth striving for. However, a lack of priority by management at all levels has hindered implementation.[12] Until support and readiness are addressed as primary program objectives, their fulfillment will be limited because cost, schedule, and performance will continue to usurp attention. Additionally, there has been some reluctance to support this initiative within the procurement community because of misconception that this initiative may limit contract flexibility, or cause extraordinary emphasis on reliability and support out of proportion to the need.[13] This is not true. In fact, the focus of the initiative is to allow the program manager and contracting officer more flexibility in tailoring incentive approaches, especially relating to reliability and support. ||

FIGURE 4
F/A-18 Incentive to Control Operating and Support Cost



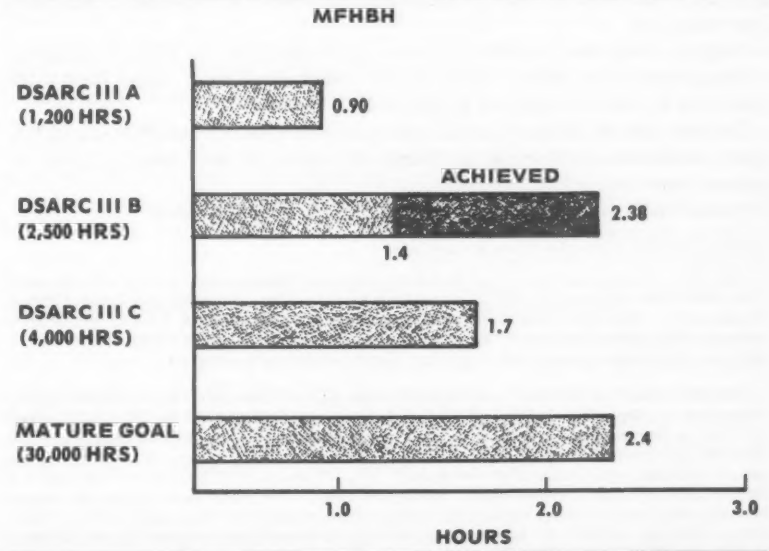
SOURCE: McDONNELL AIRCRAFT COMPANY

12. Memorandum for the Under Secretary of Defense for Research and Engineering, Subject: "Final Report of the Task Force on Acquisition Improvement," December 23, 1981.
13. *Ibid.*

TABLE IV
F/A-18 Subcontractor Reliability Development Test Items

NOMENCLATURE	SUPPLIER	TOTAL BUY	DEDICATED RELIABILITY DEVELOPMENT ITEMS
HEAD-UP DISPLAY	KAISER	22	2
COMMUNICATIONS SYSTEM CONTROL	CONRAC	24	2
ENGINE MONITOR DISPLAY	G.E.	24	2
AIR DATA COMPUTER	SPERRY	23	2
MAINTENANCE DATA RECORD SET	BENDIX	23	2

FIGURE 5
F/A-18 Reliability Thresholds and Goals



Program Stability: An Essential Element in Improved Acquisition

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Harold J. Schutt
David D. Acker

Program stability in defense systems acquisition is a myth—almost, that is. Nonetheless, it is an important concept and a worthwhile objective. Program stability is one of the conditions (sometimes an absolutely necessary condition) that permits a program to successfully meet both cost and schedule targets.

In 1981, when the first steps to initiate the DOD Acquisition Improvement Program were taken, the Office of Secretary of Defense (OSD) leadership recognized that program stability was an important objective but that it would be difficult to realize. They did not expect much improvement for FY 1982; however, some progress was expected for FY 1983. In the FY 1984 budget evolution—the first year the new administration would have full control over the budget—significant progress in establishing program stability was envisioned.

The many causes and effects of program instability will be identified in this paper. The important point to recognize is that program stability is not an isolated program consideration that can be treated separately. It results from many factors and can only be realized when all the related factors are brought under control.

Program instability, on the other hand, has created many problems. For example:

—Contractors, subcontractors, vendors, and suppliers have dropped out of the defense business. Some have gone into purely commercial business; others have gone bankrupt.

—Program delays or cancellations have caused layoffs in the defense industry.

—Companies in the defense industry have been unwilling to make capital investments that would improve productivity.

—The unit costs of defense systems and equipment have increased because of frequent production starts and stops, changes in number of units being procured, or program stretchouts.

We must find a way to reduce the number of unstable programs.

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Two issues in trying to cope with program instability are (1) The fact that the program manager can do very little to influence stability because of the nature of the defense systems acquisition process; and (2) the loss of flexibility in defense systems acquisition. The program manager can take certain actions that will lead to, and support, the concept of program stability. These actions, to be described later, have a significant, beneficial impact on program stability, but there are other items that have a more profound impact on program stability. These items, such as unstable top-line total obligational authority (TOA), are clearly beyond the realm of the program manager. To have program stability results in a loss of flexibility; therefore, at all management levels—the program manager, the service, the OSD, the Office of Management and Budget, the Congress—program stability requires that management relinquish some of its discretionary powers. Program stability requires development of and agreement to "a plan." Then the plan must be followed. Suffice it to say it is very difficult for management at any level to willingly give up its discretionary power.

The important step needed to achieve program stability is to secure agreement and cooperation of management at all levels. Once agreement has been achieved to stabilize a program, the commitment of management at all levels is mandatory if stabilization is to really be achieved.

One approach to achieve program stability was alluded to by the Principal Deputy Under Secretary of Defense for Research and Engineering, Dr. James Wade, in his July 31, 1981, memorandum on program stability. To implement this approach it will be necessary for DOD management to agree on the percentage of programs it would like to stabilize, either by number or by dollar level. Once the agreement has been made, the programs to be stabilized will have to be selected and agreed to by the services, the OSD, and the Congress. Program managers will have to provide realistic baselines for these programs. After agreement on the programs to be stabilized—taking into account such factors as economic production rates, multiyear procurement, capital investment, and other impacting actions—Congress must continue to appropriate funds for these programs when and as required. Higher-level management must maintain a "hands-off" policy, provided the program manager keeps the program on schedule and within the planned performance and cost thresholds.

Flexibility to cope with a fluctuating total obligational authority, new starts, and unexpected cost growths in other programs will have to be applied to those programs not on the stabilized list. This approach, of course, will cause more turbulence in the programs not on the stabilized list because they will have to absorb the changes previously spread over all programs. However, this appears to be the only way to achieve program stability on a few selected programs.

Background

In the April 30, 1981, memorandum from the Deputy Secretary of Defense addressing the DOD Acquisition Improvement Program, program stability was cited as one of the key issues. There were several actions in this memorandum that have an impact on program stability, but Action 4 concerns this subject directly. This is the action to be addressed in this paper. It should be recognized at the outset, however, that a single action cannot ensure resolution of the program-stability problem. Interrelationships that occur in planning, developing, producing, and deploying defense systems are so complex that any action in one area must be accompanied by actions in related areas before progress can be made.

Deputy Secretary Frank C. Carlucci stated that program stability can be accomplished by fully funding research and development, as well as procurement, at levels "sufficient to ensure efficient cost, supportability and schedule performance." Furthermore, he said that to obtain program stability, the changes to each defense system program must be held to a minimum. In the DOD Acquisition Improvement Program there are three distinct, but related, actions affecting program stability, namely:

—Action 3, "Multiyear Procurement"
—Action 4, "Increase Program Stability"
—Action 7, "Economic Production Rates"

There is a "chicken-and-egg" relationship between program stability and other actions that will have to be reconciled. The two other DOD Acquisition Improvement Program actions listed above, plus others, contribute to program stability. On the other hand, if a program is stable at some time, other actions can be implemented more easily. The question is, which drives which? A stable program permits implementation of multiyear procurement, economic production rates, and other actions. On the other hand, the same factors lead to a stable program. Program stability should be established first, through the internal discipline of holding the funding for the most important programs at a stable level. This is then enhanced through the other factors mentioned above.

Action 4, which requires development of a method to increase program stability in the acquisition process, was initiated because program instability is inherently costly in both time and money. The 47 major programs included in the Selected Acquisition Reports (SARs) of December 31, 1980, (the last SAR prior to initiation of the DOD Acquisition Improvement Program) reflected a total cost growth of 129 percent over the previous Milestone II estimates, as shown in Figure 1. Action 4 in Deputy Secretary Carlucci's memorandum stated the following:

> The most common cause for these changes is financial. The budget levels and relative priorities of competing programs force tough decisions to terminate programs, reduce the number of weapons, stretch the development programs, delay planned production, or stretch the planned buy.

Let's consider program turbulence on Army programs to illustrate what can happen in the real world. Major quantity adjustments have been made to several Army programs, the most notable being the Abrams M-1 tank, the Bradley fighting vehicle system, the Patriot air defense system, the CH-47D helicopter modernization program, and the Stinger missile program. These quantity changes, and resulting cost growth, have been driven for the most part by changes in the perceived threat. See Figure 2 for the specific changes that led to increased program costs.

Policies and Procedures

Action 4 of the DOD Acquisition Improvement Program is specific in its direction. It states:

> The SecDef, OSD and Services should:
>
> 1. Fully fund the R&D and procurement of major systems at levels necessary to protect the acquisition schedule established at the time the program is baselined, currently Milestone II.
> 2. Limit stretchouts due to funding constraints (except when mandated by the Secretary or Congress).
> 3. Establish procedures which will phase the scheduling of sequential milestones so that manpower peaks and valleys can be minimized consistent with balancing the risks.
> 4. Make only changes which are directed by changed requirements or development problems . . . .

The rationale for this direction was that it would reduce costs and save time by stabilizing schedules, quantities, and production rates.

FIGURE 1

SAR Program Stability

PROBLEM: Costs increased on 47 SAR Programs. Total Increase = 129%

CAUSES:

- 27% Economic/Inflation
- 26% Quantity Changes
- 18% Estimating Changes
- 15% Schedule Changes
- 7% Support Changes
- 5% Engr Changes
- 2% Other Changes

Quantity Changes	Schedule Changes
19 Increases	41 Increased Costs
20 Decreases	4 Decreased Costs
8 Unchanged	

The Deputy Secretary of Defense directed, as part of the DOD Acquisition Improvement Program, that during program and budget reviews by the Defense Resources Board (DRB), the service secretaries must explain and justify differences, if any, between (1) the quantity of defense systems to be produced and the funding stated as required at Milestone II, and (2) the quantity and funding in the program or budget under review at the current time. The Assistant Secretary of Defense (Comptroller) and the Director, Program Analysis and Evaluation, were directed to follow this approach in preparing the FY 1983 program objectives memorandum (POM) and budget guidance.

FIGURE 2

Examples of Program Turbulence in the Army

ABRAMS M-1 TANK

Increased number of tanks from 3312 to 7058
Added 120mm Gun System
Increased spares, training equipment and support equipment

BRADLEY FIGHTING VEHICLE SYSTEM

Increased number of vehicles from 2410 to 6882
Added two-man turret with Tow and Bushmaster
Added requirement for drive viewer
Increased spares, training equipment and support equipment

PATRIOT AIR DEFENSE SYSTEM

Reduced number of fire units from 234 to 103
Changed airborne guidance to modular/digital design
Increased spares, training equipment

CH-47D HELICOPTER

Increased number of aircraft from 361 to 436

STINGER MISSILE

Increased number of missiles from 22,980 to 30,453

On July 31, 1981, Dr. James Wade promulgated a follow-up action in the memorandum on program stability addressed earlier. The memorandum stated the following:

> . . . it is generally acknowledged that the portion of the Federal budget which can be allocated to defense is not enough to efficiently fund all of the programs we currently have in the acquisition process and in the field . . . .
>
> I believe it is of the utmost importance that we commit ourselves to pursue only affordable programs, i.e., those which can be executed in a streamlined manner and transitioned into production through orderly buildups to efficient economical production rates . . . .
>
> We will have to cancel or truncate certain programs to fit our remaining requirements within budget constraints. New starts will of necessity receive extreme scrutiny with increasing likelihood of being product improvements rather than new technological developments . . . .

In the Wade memorandum the services were directed to "submit (in about 30 days), candidate programs for *DOD stable programs list.*" (Emphasis added.) Furthermore, Dr. Wade said that:

> Selections should reflect your *long-range planning* and *budget forecasting* effort, conform to existing and ongoing *plant facilitizations*, recognize *future manpower* and *critical skill level constraints* and strike a *balance* between *modernization* and *readiness* requirements.
>
> We are committed to delineating for the Congress those programs which must be cancelled or deferred as a consequence of the FY 1983 budget review . . . . join me in making necessary future choices on program cuts. First attention should go to *poor cost and technical performers* . . . . Look very critically at programs that have experienced *excessive* and *recurring cost growth* and whose *ultimate cost is unpredictable* or *out of control*. If we elect to continue such systems, we should have a program alternative that entails *production competition* . . . .
>
> . . . Our *credibility* in the management of the large public expenditures being allocated for defense is dependent to a large measure on our ability to handle our affordability problem effectively. (Emphasis added.)

In Dr. Wade's memorandum three significant items emerge, namely: (1) Recognition of the complex interrelationships between program stability, other actions in the DOD Acquisition Improvement Program, and overall affordability; (2) The importance of other decision-makers, e.g., the OMB, and the Congress, in the accomplishment of program stability; and (3) The genesis of an approach to achieve program stability.

Service Participation

As a result of Dr. Wade's memorandum, the services conducted a comprehensive analysis of their current and proposed programs, and submitted specific programs for placement on a DOD stable-programs list. The Army list contained the CH-47 helicopter, the Abrams M-1 tank, the Bradley fighting vehicle system, and the UH-60 Black Hawk helicopter. The Air Force list contained 13 programs, and the Navy list contained 20 programs. These programs should be prime candidates, not only for the stable-programs list, but also for multiyear procurement, which can provide a 10 to 20 percent reduction in cost.

One of the programs the DOD is stabilizing and committing to multiyear procurement is the F-16. As *The Washington Post* reported recently:

> General Dynamics Corporation has received the first part of a record $3 billion contract with the Air Force to build 480 F-16 fighter jets during the next four years. The $480.5 million contract awarded by the Air Force . . . . assures General Dynamics of at least four years of stable production at the rate of 120 planes a year.[1]

The analyses made by the services revealed a key issue relative to establishing program stability. That is, program stability can be achieved by (1) increasing the total obligational authority or (2) reducing the scope of other programs (or even cancelling them). Generating a list of stable programs using the first approach would be "easy" if unlimited funds were available—but they are not. Using the second approach would require an extensive and comprehensive analysis. This is not a simple task. To implement this approach effectively, a service must review the basic mission need, evaluate the threat, consider ongoing programs (which translate into capabilities), and, most importantly, consider what capabilities may be lost by the reduction or termination of programs considered less important than those being "stabilized."

Status of Implementation

The most recently published, comprehensive report on the status of the DOD Acquisition Improvement Program was issued in December 1981.[2] In the introduction to that report, William A. Long, Deputy Under Secretary of Defense (Acquisition Management) states: "We have gone a long way toward our stated objectives (to make substantial improvements in the defense systems acquisition process), but have met some barriers." The report states the following relative to program stability (a major portion of this report is quoted here for the benefit of those who wouldn't otherwise have an opportunity to read it):

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1. *The Washington Post*, 28 January 1982.
2. Department of Defense Acquisition Improvement Task Force Report, 23 December 1981.

. . . a major portion of the ultimate success of the Acquisition Improvement Program can be directly related to the degree to which programs are stabilized. Although some progress has been made, significant problems remain.

To achieve greater program stability, we must also achieve a greater degree of stability in the Service "topline" budget guidance. Many factors influence the topline guidance including ones outside of DOD. If this guidance changes significantly during the year as programming and budgeting decisions are being made, each Service must continually make adjustments and rebalance its program. Greater stability in topline guidance will help substantially to alleviate the problem. This is a key element of the Acquisition Improvement Program and, because it is largely outside the control of the Services, the highest levels within the Department of Defense must address this matter on a continuing basis.

Effective implementation of the initiatives connected to stabilization requires their immediate incorporation into the planning process. The Fiscal Year 1984 Defense Guidance must reflect the thrust of the Acquisition Improvement Program. In the near future, OUSDRE and MRA&L will brief the Defense Resources Board on the mismatch between requirements and the resources in the Draft Guidance. Solutions must be found which are consistent with the Acquisition Improvement Program. Otherwise, problems are certain to arise in the Fiscal Year 1984 POMs and full implementation of the initiatives may be slowed.

Important procedural steps toward near-term stabilization such as improved guidance, a stable programs list, and a special Defense Resources Board meeting on new starts and economical production rates were implemented during the Fiscal Year 1983 program and budget review . . . .

Unforeseen reductions during development of the Fiscal Year 1983 budget contributed to destabilization of a number of acquisition programs. Some programs which had been restored to more economical production rates through the Fiscal Year 1981–82 Budget Amendment subsequently were proposed for cancellation, reduction, or stretchout in order to meet the new fiscal constraints. Follow-on action by the Defense Resources Board to restore economical production rates only partially compensated for the cutbacks. The balance between across-the-board responses to threats and program stability is difficult to strike, but unless we reduce the number of programs, and at the same time preserve the required funding for our "stable" programs, our Acquisition Improvement Program will not succeed.

The Defense Resources Board met recently to consider all of the "new start" major programs for Fiscal Year 1982. Eleven were approved, three were not approved, and two were restructured. The

> "new start" review is an important addition to the programming phase and should be retained for numerous reasons. Although care must be taken to review new starts from a variety of mission standpoints and not to overstate the linkage between new starts and program stability, there is some relationship between the two.

Current Activities

In testimony before the House Armed Services Committee on February 9, 1982, concerning the DOD authorization for appropriations for FY 1983, Deputy Secretary Carlucci stated:

> . . . In the area of *economic production rates*, we have found many instances where capacity exists, or will be financed by industry, to enable the production of the quantities of equipment required for Defense at higher rates and, therefore, at lower unit costs. During 1981, we held special meetings of the Defense Resources Board to make a special effort to take advantage of the possible increases in efficiency and unit cost savings that can result from higher, more efficient rates. We added $3.4 billion in the FY 1983 budget request to fourteen selected programs in order to raise FY 1983 rates (outyear production rates were raised as well) to more economical levels. As a result of these decisions, we expect to save (a net) of $2.3 billion during the next five years in procuring the quantity planned before the increase. Of course, we will also receive additional quantities of hardware during this period.

See Figure 3 for the details of the FY 1983 TOA increases and net savings

Actions Program Managers Can Take

There are eight actions in the DOD Acquisition Improvement Program that program managers can take to enhance program stability and improve cost effectiveness. These actions are as follows:

BUDGET TO MOST LIKELY COST (ACTION 6)

In order to ensure high-level cooperation in all the activities that perpetuate program stability, it is mandatory that program managers continue to provide cost estimates that are as realistic as possible. Also, it is critical that these cost estimates not be changed for the sake of getting the program approved and funded by the Congress.

IMPROVE THE SOURCE SELECTION PROCESS (ACTION 20)

One of the objectives of Action 20 is to improve the source-selection process by placing added emphasis on past performances, schedule realism, facilitization plans and cost credibility. This procedure should eliminate poor performers and

proposals that are unrealistically priced. This, in turn, reduces the risk of buy-ins, which is addressed in greater detail in the article by Manfred J. Reinhard in this issue.[3]

FIGURE 3

Economic Production Rates ($ in millions)

	FY 1983 TOA INCREASE	NET 7-YEAR SAVINGS
AIM-9M Missiles	—	74.2
E-3A Aircraft	—	159.0
F-15 Aircraft	1,072.1	42.6
RF-4 IR Sensors	19.3	13.1
Defense Satellites	207.2	64.0
AN/SSQ-47 Sonobuoys	—	3.2
AN/BQQ-5 Sonars	—	1.3
TSEC/KG-45	2.8	.8
SH-60B Helicopters	55.7	217.5
CH-53E Helicopters	81.8	20.9
Common ECM Equipment	61.7	18.5
A-6E Aircraft	109.6	58.4
EA-6B Aircraft	169.6	36.8
F-14 Aircraft	562.5	70.9
F-16 Aircraft	435.8	747.0
Laser HELLFIRE Missiles	130.0	189.8
Fighting Vehicle Systems	141.3	236.0
DIVAD Gun Systems	349.0	313.1
	3,398.4	2,267.1

NOTES: Includes only the incremental cost of the FY 1983 quantities that were added to the previously planned buy in order to attain the beneficial economies shown in the "savings" column.

Savings accrue due to lower unit costs resulting from increased efficiencies gained by higher production rates.

3. Manfred J. Reinhard, "Improving the Source Selection Process."

PROVIDE MORE APPROPRIATE DESIGN TO COST GOALS (ACTION 22)

Action 22 is intended to provide industry with incentives by associating fee award with actual costs achieved during early production runs. This action ties the award to "real" achievements and makes the design-to-cost concept meaningful. A more complete discussion of this topic is provided in the article by Major Raymond H. Barley.[4]

Action 20 and 22 directly support Action 6 to provide more realistic cost estimates. These actions, in turn, support program stability.

BUDGET FOR INFLATION (ACTION 18)

Program managers should take advantage of the new inflation rates that have been promulgated. If necessary, special inflation rates should be requested if they are appropriate to the type of defense system being acquired. Economic price adjustments (EPA) may also be applied. More details on EPA clauses is provided in the accompanying article by Dr. Andrew P. Mosier.[5]

BUDGET FOR RISK (ACTION 11)

It is important to consider the risk of technology proposed for use in the defense system when estimating costs. One approach to considering risk is demonstrated in the Army's TRACE program. This subject is covered in greater depth in the article by Lieutenant Colonel John D. Edgar.[6]

ECONOMIC PRODUCTION RATES (ACTION 7)

Economic production rates tend to stabilize programs; however, in recent years, economic production rates have not been achieved on major defense systems programs. This has been due, for the most part, to the funding bow waves experienced in each service. The funding bow waves have been caused by more program starts than could be afforded, by unrealistic cost estimates during the advocacy phase of each program, from optimistic estimates of economic escalation, and because of revolutionary defense system designs.

The use of economic production rates (EPRs) may result in a cost savings of as much as one-third of the production costs. Furthermore, the operational obsolescence of a defense system could be reduced by providing the new capability to the field units in a shorter time. Support costs could also be reduced by avoiding design changes caused by technical obsolescence of critical components. In addition, savings can be made by providing spares from the production line until the design has matured.

To date, success in achieving EPRs has been limited. Considerable effort has gone into cost models to portray savings; however, budgetary limitations have

4. Major Raymond H. Barley, USAFR, "Design-to-Cost and the Acquisition Improvement Program."

5. Dr. Andrew P. Mosier, "Enhancing Productivity Through Increased Capital Investment."

6. Lieutenant Colonel John D. Edgar, USAF, "Controlling Murphy: How to Budget for Program Risk."

restricted achievement of EPRs on a number of programs. This subject will be given special consideration at future DSARC milestone and program reviews. In some cases, achievement of EPRs may be dependent upon cancellation or delay of new starts where product improvement of an existing system offers a viable alternative.

MULTIYEAR PROCUREMENT (ACTION 3)

Multiyear procurement can result in a savings of as much as 10-20 percent of program costs. This approach should be seriously considered for programs meeting the criteria. This approach is another element of stable program strategy. Multiyear procurement is covered in detail in the article by Dr. Abraham Singer.[7]

PRE-PLANNED PRODUCT IMPROVEMENT (ACTION 2)

A system can be fielded sooner if product improvements not yet fully developed to meet the ultimate capabilities are capable of installation as modules in the future. This approach, generally referred to as P^3I, is discussed in the article by Lieutenant Colonel Garcia E. Morrow and Dr. Jules J. Bellaschi.[8]

As indicated earlier, many actions in the DOD Acquisition Improvement Program support and facilitate program stability. Examples of this follow:

—P^3I stabilizes a program by minimizing the possibility of disruptive technical problems.

—Budgeting for inflation allows program managers to make a more accurate estimate up-front instead of being impacted every year with cost growth due to "unanticipated inflation."

—Budgeting for technical risk allows program managers to make intelligent allocations for the lightning they know will strike somewhere—thus, once again, helping program managers to minimize the potential impact of disruptive technical problems.

—Economic production rates offer significant cost savings and more stable costs. Stabilized costs over longer time periods benefit overall program stability.

—Budgeting to most-likely cost will result in more realistic cost estimates. Good initial-cost estimates will reduce subsequent-year cost fluctuations from "revised estimates" in subsequent years. This will stabilize the budgeting process and facilitate program stability.

—Supporting more stabilized cost estimates are actions to improve the source selection process and to provide more appropriate design to cost goals. Both of these actions are designed to produce more realistic cost estimates that will be maintained during the production period.

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7. Dr. Abraham Singer, "Enhanced MYP for Improving Weapon Systems Acquisition."
8. Lieutenant Colonel Garcia E. Morrow and Dr. Jules J. Bellaschi, "A Cultural Change: Pre-Planned Product Improvement."

Summary and Final Thoughts

Is there any hope for stabilizing defense systems programs? Yes, but it may take several years to achieve the objectives sought in the DOD Acquisition Improvement Program. It is conceivable that there is only one approach that will effectively work to achieve any kind of program stability. That approach is alluded to in the Wade memorandum. The DOD, in conjunction with the OMB and Congress, may have to select a few programs to stabilize. Once agreed to, the program funding must be provided as required to meet the agreed production rate and schedule. The program must not be changed except for a perceived change in threat, or for a catastrophic reason. Above the program manager, the principles of "management by exception" should be adhered to, and the program should be allowed to proceed without micromanagement from higher levels. After program authorization by Congress, assuming the agreed-to schedule is maintained, the program appropriation must be automatic and must be available when required. This is a different *modus operandi* than currently exists, and it will require a high degree of trust and some rethinking by high officials. Without mutual trust and commitment, program stability cannot be achieved.

At this time, only a few carefully selected programs are being considered for placement on the stable-programs list. The others will run the risk of destabilization when higher priority programs require additional resources. Without such an arrangement, DOD and the services will not have sufficient space in which to maneuver to meet changes in the perceived threat or higher costs.

It is acknowledged that the key issue of flexibility vs. program stability is of more concern to management levels above the program manager; therefore, the program manager has little influence in these areas. The program manager can play a key role, however, in setting the climate for tilting the balance in favor of program stability. If the best budget estimates possible—with a minimum chance of future "cost overruns"—are submitted to OSD and the Congress, program stabilization may be possible, if the program is not acted upon by outside sources.

By properly executing the actions described in this article, as well as those actions covered in detail elsewhere in this issue, program managers will be able to make a valuable contribution to the DOD Acquisition Improvement Program.||

Readiness—Coequal

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Colonel G. Dana Brabson, USAF
Dr. John P. Solomond

The Office of the Secretary of Defense and the services have united in an effort to significantly enhance the readiness of U.S. forces. Here are the key elements of this attack:

—Develop readiness objectives early in each program and allow these objectives to guide decisions throughout the program.

—Invest in those elements of technology that increase reliability and ease maintenance requirements.

—Invest in test and evaluation programs that accelerate the maturation of technology.

—Invest in product improvement programs that seek to enhance reliability and supportability.

—Involve industry in the development and production of systems that are inherently reliable and maintainable.

—Place additional management emphasis, at all levels from the DSARC through the program manager, on readiness as a key objective.

The purpose of this paper is to focus your attention on the key elements of this strategy, and to provide information that will help you apply this strategy to your program. The primary focus is on two of the 32 actions that constitute the DOD Acquisition Improvement Program: Action 9, Improve System Support and Readiness; and Action 31 (Issue H), Improving Reliability and Support for Shortened Acquisition Cycle. However, attention will also be given to several other actions including Action 12, Provide Adequate Front-End Funding for Test Hardware; and Action 30 (Issue G), Program Manager Control over Logistics and Support Resources.

Background

During the past two decades there has been a growing realization that support has not been given adequate attention. The situation is exacerbated by the fact that operations and maintenance costs are growing at a rate that far outstrips inflation, and by the fact that our pool of highly skilled repair and maintenance personnel is shrinking. As early as the beginning of the '70s, the DOD

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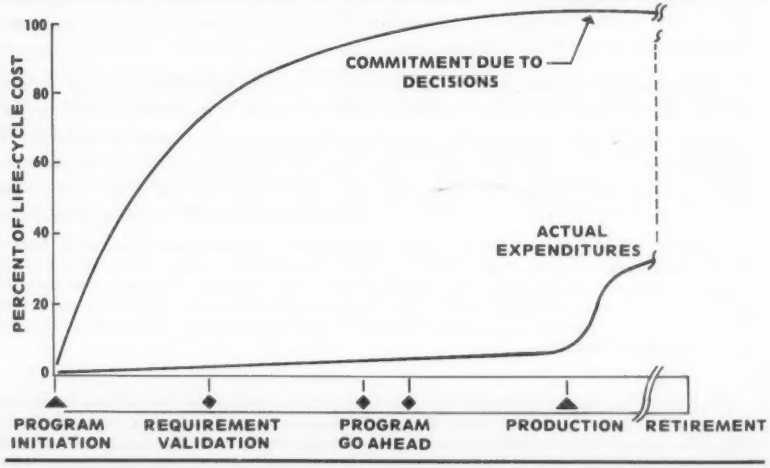
laboratories recognized and articulated the need to shift resources to those projects that emphasized supportability and maintainability. By the mid-'70s, concern with our lack of readiness had become an issue of national importance. Congress, the DOD, and the services, working in concert, began taking stiff measures to reverse the trend toward a weakened readiness posture. Finally, on April 30, 1981, the Deputy Secretary of Defense signed his memorandum on improving the acquisition process. Especially noteworthy in this memorandum is the following fundamental management principle relating to readiness.

> Improved readiness is a primary objective of the acquisition process of comparable importance to reduced unit cost or reduced acquisition time. Resources to achieve readiness will receive the same emphasis as those required to achieve schedule or performance objectives. Include from the start of weapon system programs designed-in reliability, maintainability and support.

Before going into the individual requirements of the DOD Acquisition Program, you should understand two important features of the life cycle of a typical major weapon system: (1) More than half of the life-cycle costs of a system are incurred *after* deployment; and (2) decisions made very early in the life cycle strongly influence the costs of operation and maintenance. These points are illustrated by Figure 1. (The data displayed here are characteristic of a large

FIGURE 1
Life-Cycle Cost of a Typical Weapon System



weapon system such as a ship or aircraft. Munitions represent a different class of systems and are, usually, characterized by expenditures after initial operational capability that are a significantly smaller portion of the total life-cycle costs.) Note that, while roughly two-thirds of the life-cycle cost of a system is incurred after production, decisions made before the initiation of the demonstration/validation phase of the program dictate about 70 percent of the life-cycle costs for the system. By the time the production decision has been made, roughly 95 percent of the life-cycle costs have been defined. This does not mean that the life-cycle costs cannot be influenced after Milestone III; it simply means that the program manager has a great deal of leverage during early phases of the program and that this leverage rapidly diminishes as the program matures. In this context, it is not surprising that the DOD Acquisition Improvement Program places heavy emphasis on "up-front" activities, including planning, research, development, testing, and evaluation.

Readiness Objectives

First and foremost among the up-front activities is the statement of readiness objectives to be achieved by the new weapon system. These objectives provide the framework within which support decisions can be made throughout the life cycle of the system.

The requirement for readiness objectives was established by Action 9 of the Acquisition Improvement Program and was fleshed out by the June 13, 1981, DEPSECDEF memorandum on readiness and sustainability.[1] The strongest statement of the requirement for readiness objectives is contained in the recently issued DOD Directive 5000.1: "Readiness goals . . . shall be established early in the acquisition process, and shall receive emphasis comparable to that applied to cost, schedule, and performance objectives." DOD Instruction 5000.2, when issued, will deal at length with the requisite procedures; however, even in its absence, a cohesive picture emerges.

First, the readiness objectives, or goals,[2] should be established very early in the life cycle of a program, preferably around Milestone 0 (the program initiation). Naturally, at this point, it will be necessary to state objectives in the broadest terms—in terms of the overall capabilities to be achieved by the system. These objectives provide the basis both for the logistics strategy and for the acquisition strategy, which are laid out at Milestone I. They also serve as guidance to the designer and help him flag those areas in which innovative designs and design trade-offs may be required. In a very real sense, the designer adopts design goals for readiness much as defense planners traditionally have used design goals for performance parameters.

1. Deputy Secretary of Defense Memorandum, "Readiness and Sustainability in Acquisition Programs," June 13, 1981.

2. The terms "objectives" and "goals" appear to be used interchangeably in the available literature.

As the system evolves, the readiness objectives are restated in more specific terms. Typically, two sets of goals will be required: those to be achieved at early fielding, and those expected at maturity. This process thus recognizes the natural maturation of technology that occurs after the system has been fielded and hands-on experience has been gained.

It is important, of course, to define the readiness goals so that they can be quantitatively related to measurable parameters such as hardware characteristics, manpower resource requirements, and logistic resource requirements. The goals should include hardware reliability, expressed as some point estimate, e.g., mean time between failure (MTBF), or mean miles between failure (MMBF), as well as operational availability, sortie rate, mission capable rate, etc. The important issue to keep in mind here is that achievement of these readiness goals can be tested by direct measurement augmented by analysis using computer simulation or other techniques. One of the strengths of simulation is its worth as a vehicle for the evaluation of readiness goals without the expense in time, manpower, and equipment necessary for the traditional field measurement of military utility.[3]

During the past several months there has been a great deal of discussion among the services as to what parameter or parameters best typify the readiness of a system. There is a desire to focus on a single parameter if possible, because this would facilitate intercomparisons and simplify the overall process. As of this writing, there is a trend toward the use of operational availability (A_o) as that single parameter. Inasmuch as operational availability is expressed as the ratio of uptime divided by total time, it is a measure both of the field reliability and the supportability of the hardware. Mathematically, the operational availability can be calculated as follows:

$$A_o = \frac{MTBF}{MTBF + MDT}$$

where: MTBF = mean time between failures
MDT = mean downtime

Note that the mean downtime includes a wide variety of parameters such as mean time to repair (MTTR), mean logistics delay time (MLDT), and mean downtime awaiting maintenance; thus, the single term A_o includes nearly all the relevant support and readiness characteristics. It should be noted in passing that, as a matter of policy, the Navy has adopted operational availability as its primary measure of materiel readiness.[4]

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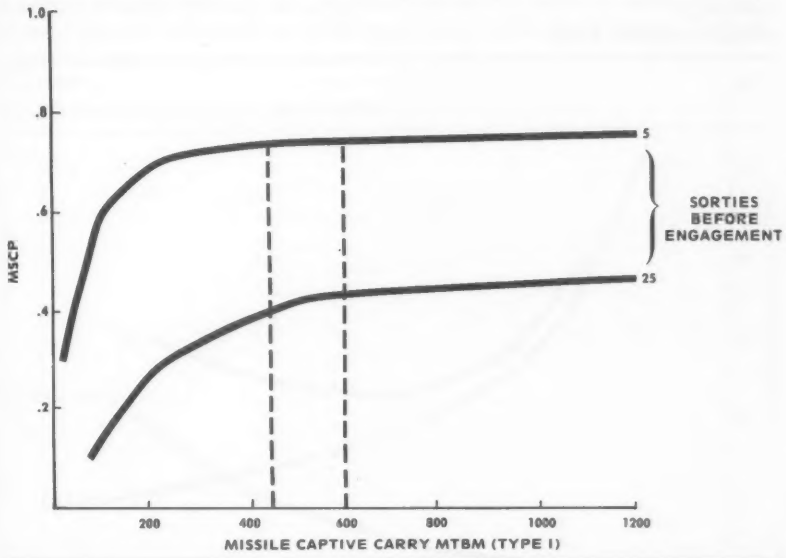
3. Michael F. McGrath and Matthew G. Henry, "Logistics Simulation—A Credible Tool to Decision Makers?" *IEEE Transactions on Reliability*, R-30(3), 258-264, August 1981.

4. NAVMATINST 3000.2, "Operational Availability of Weapon Systems and Equipments; Definitions and Policy," January 21, 1981. This instruction gives an extensive discussion of A_o, equations, and sample calculations.

In addition to readiness goals, readiness thresholds should be identified. In this context, goals are defined as parameter values that will enable the new system to satisfy fully mission needs, while thresholds are those values that describe either a minimum performance level or a maximum expenditure of resources for a new system. The risk associated with a particular acquisition program is reflected in the variance between these goals and thresholds at any particular milestone.[5]

Two programs exemplify the principles we have been discussing in this section. The first is the Advanced Medium Range Air-to-Air Missile (AMRAAM) program. The joint service operational requirements (JSOR) for this system, published in 1976, contained reliability and maintainability thresholds and goals. Subsequently, these thresholds and goals have been translated into contractual terms, which will be measurable and enforceable during full-scale development and production.

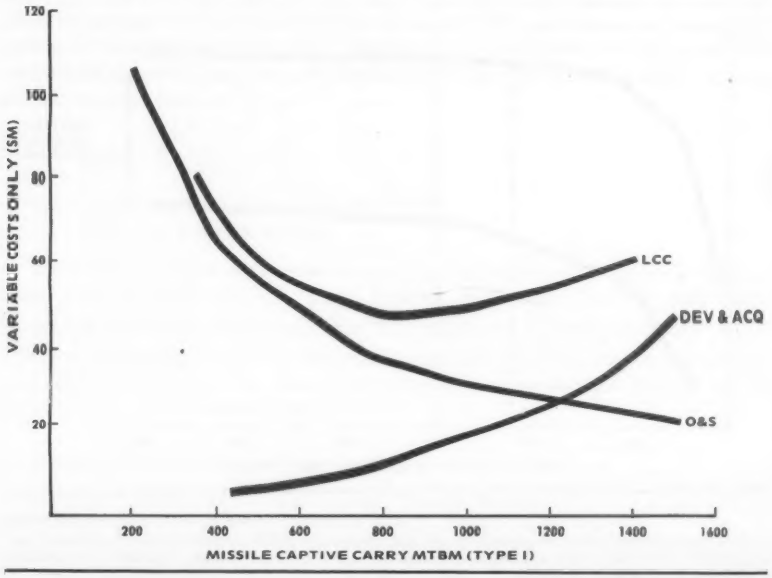
FIGURE 2
Requirements: MCSP



5. These concepts of management goals and thresholds differ somewhat from the statistical measures of goals and thresholds as promulgated in such documents as MIL-STD-781-D, *Reliability Testing for Engineering Development, Qualification, and Production.*

The principal measure of readiness for the AMRAAM is the mission completion success probability (MCSP), defined as the fraction of production missiles that successfully arrive at the target. Needless to say, an important component of the MCSP is the mean time between maintenance (MTBM). The relationship between these two parameters is illustrated by Figure 2. It is immediately apparent from these data that efforts to improve the MTBM beyond about 500 hours offer very little improvement in overall mission performance as reflected by the MCSP. To place this conclusion on a firmer basis, both the cost of achieving a particular MTBM and the cost of supporting the system given a particular MTBM were plotted as a function of MTBM (see Figure 3). The net result was a classic "bathtub" curve with a minimum at an MTBM of about 800 hours. This is just one of numerous trade studies that were performed using quantitative estimates of reliability and maintainability as key variables. Other examples include an analysis of the optimum storage life, evaluation of alternate support concepts, and estimation of the relative value of a built-in test (BIT) capability, to name a few.

FIGURE 3
Requirements: Cost

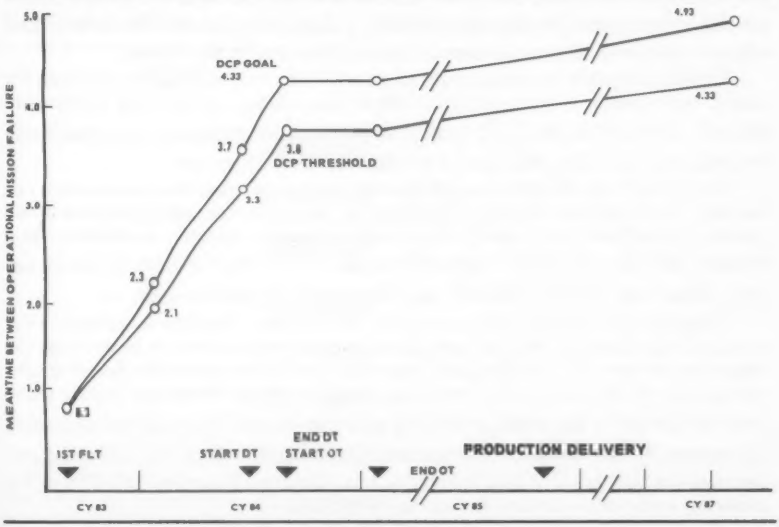


The second program of interest is the Army Helicopter Improvement Program (AHIP) to develop and field an improved scout helicopter based on the OH-58. Because this is a modification of an existing helicopter design, the program began with full-scale engineering development (FSED) on October 30, 1981. The principal support-related figure of merit for this program is the mean time between operational mission failure (MTBOMF), which is the mean time between failures that would cause the mission to be unsuccessful. In consonance with the requirements of Action 9, goals and thresholds have been established for this parameter as a function of the phase of the life cycle. These data are displayed in Figure 4. This chart will be used to measure the progress toward achieving the contractually specified reliability and maintainability (R&M) requirements. The contract incorporates numerous provisions, such as the test-analyze-and-fix (TAAF) program, to facilitate the maturation of technology and achievement of the R&M requirements.

Investment in Technology

Once the readiness objectives for a system have been defined and the readiness strategy laid out, the program manager can begin to invest in those technologies that will result in achievement of the readiness objectives. Among

FIGURE 4
AHIP Projected Growth Estimates



the investment opportunities are those that make the systems inherently more reliable, thus reducing the need for maintenance. In addition, there are those investments that make the maintenance tasks easier and less time-consuming.

DESIGN FOR RELIABILITY (ACTIONS 9, 31)

Obviously, the inherent reliability of a system directly influences the amount of maintenance that will be required, and the number of spares that will be needed. Thus high reliability is a goal to be sought not only to assure effective performance but also to reduce support requirements.

As Willis J. Willoughby, Deputy Chief of Naval Material for Reliability, Maintainability, and Quality Assurance, points out, the reliability of a system is primarily a function of the stress to which each component of the system is subjected. Reliability is normally achieved by avoiding the use of materials and components near the boundaries of their performance envelopes. The potential conflict of this strategy with weight and volume contraints is immediately apparent. Accordingly, it is crucially important for the program manager to understand the "real" reliability requirements and be prepared to make cost-effective trade-offs. It is appropriate to note here that most military hardware is designed for a medium level of reliability; higher levels of reliability are required only when the safety of personnel is a factor and when the equipment (such as a satellite) cannot be repaired once it has been put into operation.

Before the design engineer can begin his tasks, he must thoroughly understand the mission of the system and the environment to which it will be exposed. Based on this information, he develops reliability design criteria for the system and allocates the reliability requirements for each element in the system.

There is a variety of design techniques available to the designer. Perhaps the oldest and most time honored is the use of redundancy. In the new fly-by-wire aircraft, for example, the flight control system may have triple or even quadruple redundancy, and may also have a mechanical back-up system.

With the advent of high-speed electronic systems, a new phrase is entering our lexicon: "fault-tolerant designs." We think of fault-tolerant designs largely in the arena of computers, particularly those to be flown on satellites. In essence, these systems have the capability to detect the existence of a fault, isolate the faulty element, insert an alternate element, and then proceed with the task.

Derating is, of course, the standard of the industry. Derating is defined as the reduction of electrical, thermal, and mechanical stresses on a part to decrease the degradation rate and prolong the expected life of the part. By derating, the margin of safety between the operating stress level and the actual failure stress level for the part is increased, providing added protection from system anomalies unforeseen by the designer. Consequently, intelligent component derating will decrease the likelihood of catastrophic failure. Derating is accomplished by either reducing stress or increasing the rating of the part.

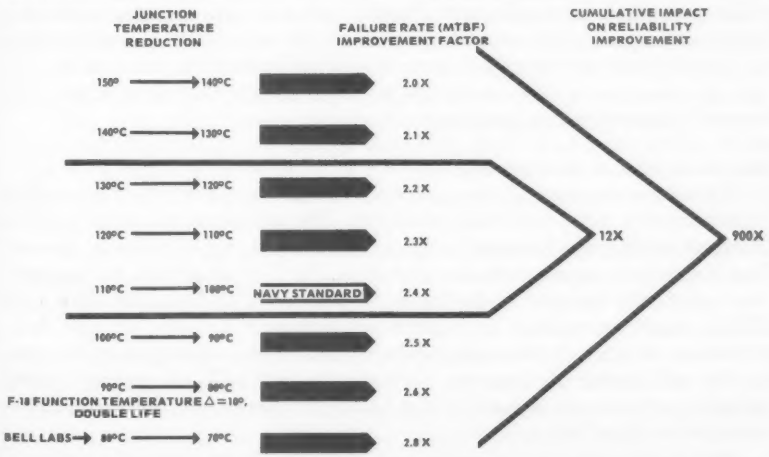
A quantitative illustration of the impact of reducing the stress on a component is given by Figure 5. Some military systems operate with semiconductor junction temperatures as high as 150°C. By contrast, typical systems developed by Bell Laboratories operate at 70°C. As shown by the figure, there is an approximately 900-fold difference in mean time before failure for a typical component operated at these two extremes. The Navy has adopted 110°C as its standard, and the equipment aboard the F/A-18 aircraft actually operates at a temperature 30°C lower than this standard.

In the case of the P3-C patrol aircraft, the Navy redesigned the cooling system for the electronic cabinets in the cabin, reducing the average rack temperature by 20°F, and estimates an annual savings in operating costs of $42 million.

The Army Helicopter Improvement Program is also taking advantage of advances in technology to reduce operating and maintenance costs. Use of a tungsten-plated swashplate ball will result in roughly a 50 percent improvement in swashplate assembly MTBF. The use of fiberglass blades and a composite main rotor yoke will significantly reduce the frequency of corrosion problems. (Inasmuch as these composite components have non-catastrophic failure modes, they also increase flight safety.)

The full-scale development program for the F-101-GE-102 engine for the B-1B aircraft is likewise capitalizing on advanced materials and design techniques to

FIGURE 5
Junction Temperature Impact on Semiconductor Reliability



significantly improve its reliability with respect to its predecessor, the F-101-GE-100. Examples include an improved exhaust nozzle, three fewer stators on the fan frame, a thermal-barrier-coated combustor, a redesigned augmentor (afterburner) fuel pump, and a redesigned central integrated test system (CITS) processor.

One last point should be made regarding improved reliability: Analytical-experimental techniques play a major role in validating and improving the design, including failure-mode effects and criticality analysis, worst-case analysis, and sneak-circuit analysis. Failure-mode effects and criticality analysis identify single and multiple failure modes and the incorporation of corrective action to improve the fault-tolerant capabilities of the design. Sneak-circuit analysis is used to identify system interfaces and auxiliary equipment in order to find and eliminate any latent ("sneak") electrical paths, which cause undesired, or inhibit desired, functions.

MANUFACTURING TECHNOLOGY (ACTION 5)

The manufacturing technology programs of the three services are particularly effective tools in that they not only facilitate the maturing of new technology, but also help transfer the new technology to the plant floor. Because the manufacturing technology programs are discussed in greater detail elsewhere in this issue,[6] a single example will suffice to illustrate how a MANTECH program facilitated the application of a new technology with significant potential for maintenance cost reduction. A particularly nagging problem with the C-141 fleet is maintenance of the leading edge slats. The original structures, made of conventional aluminum honeycomb, are subject to corrosion and foreign-object damage. Under the Air Force manufacturing technology program, ten slats were manufactured using graphite-fiberglass-epoxy technology. Nine of these new slats are currently flying on Air Force aircraft; the in-service experience gained to date shows that the new slats are exceptionally resistant to foreign-object damage and are immune to the type of corrosion that plagued their predecessors.

DESIGN FOR EASE OF MAINTENANCE

From time immemorial some aspects of design have specifically considered maintainability as an important parameter. The aircraft access panel with its standard quick-access fasteners is a case in point. The opportunities for innovation in this arena appear to be almost endless. The F/A-18 aircraft, for example, was specifically designed so that most (89 percent) of its line-replaceable units (LRUs) could be reached by maintenance personnel standing on the deck. Moreover, very few of the access panels are load bearing, thus reducing the complexity and number of fasteners. Similarly, the F-101-GE-102 engine is being designed with numerous features that facilitate maintenance. Some illustrative examples are listed below:

6. Dr. Andrew P. Mosier, "Enhancing Productivity Through Increased Capital Investment."

—Borescope ports allow inspection of fan blades, most compressor blades, and all turbine blades while the engine is in place.
—The split-case design of the fan and compressor allows access for inspection, minor repair, and individual blade replacement without complete engine tear down.
—All externally mounted accessories are accessible while the engine is installed in the airframe.

TEST EQUIPMENT

Test equipment, both automated test equipment (ATE) and built-in test (BIT) equipment, is receiving more attention. This is driven in part by the increasing sophistication of the weapon systems, and in part by the declining number of highly skilled maintenance personnel.

Here again the F/A-18 aircraft is an excellent example. In all, more than 500 F/A-18 equipment items are monitored on the maintenance monitor panel (MMP) located in the nosewheel well; when an inflight failure occurs, the master monitor display in the cockpit indicates which subsystem or function has failed. Once on the ground, the digital display on the MMP gives maintenance personnel a more specific indication of the fault and its location. The built-in test in the F/A-18's AN/APG-65 multi-mode radar system is designed to detect 98 percent of all faults and to isolate the fault to a single weapon-replaceable assembly (WRA) 99 percent of the time.

It would be a mistake to claim that ATE or BIT have proved to be the answer to the repairmen's dreams. Indeed, such equipment has proved to be complex in its own right and suffers its own reliability and maintainability problems. With these concerns in mind, the Office of the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics sponsored a workshop in the requirements for built-in test equipment. A review of some of the pertinent observations is appropriate at this point.[7]

First, even though more and more BIT-equipped weapon systems are being introduced, most are not meeting the diagnostic specification goals of 90 to 95 percent probability of automatic fault detection and isolation. Furthermore, recent experience shows that 20 to 40 percent of the items replaced because of a BIT-indicated failure were later found to be serviceable.

Second, BIT is not designed to detect all failure conditions; consequently, additional trouble shooting is required to augment the automatic capability, and is particularly needed for the more difficult maintenance problems.

Third, the skill levels required for BIT system maintenance often exceed the skill levels available within the pool of maintenance technicians. In many cases, there has been insufficient test time (or test articles) to develop BIT in our complex systems prior to putting these systems in the field. Laboratory demonstration

7. IDA Paper P-1600, "Built-in-Test Equipment Requirements Workshop," August 1981.

tests in accordance with MIL-STD-471 do not provide reliable predictions of BIT performance in the field.

Fortunately, all of these observations are traceable to the fact that the technology associated with BIT is in an early stage of maturation. We can, therefore, look forward to significant improvements in the future; however, the program manager and his design team must be aware of the potential pitfalls of relying heavily on BIT and ATE, and must be prepared to invest the resources necessary to bring the technology to an appropriate level of maturity for the particular program.

REDUCED SUPPORT TAIL

The capstone of Action 9 is the recommendation that each service target a small number of force elements for special emphasis, with the objective of achieving a major improvement in designed-in supportability and a significantly reduced dependence upon the support "tail." Many current systems require an entourage of support-equipment vans, fuel trucks, ammunition trailers, maintenance units, test sets, and so forth; this is the support tail we want to reduce. In essence, Action 9 requires the identification of a group of systems that will serve as test beds for the various disciplines described in earlier paragraphs, including designed-in reliability and designed-in maintainability.

Investment in Test and Evaluation

While it is clearly important to invest in technology for reliability and support, it is equally important to validate this technology by an effective test and evaluation program. Traditionally, RDT&E programs have been characterized by an orderly sequence of serially scheduled test efforts. Without a doubt, this is the most efficient method from the point of view of expenditure of resources; the results of each test can be evaluated and fixes can be made before the next test begins.

However, as pressure has increased to shorten the acquisition cycle, we have responded frequently by lopping off elements of the test program and by drawing down on T&E resources to provide additional resources for development. In essence, we have made conscious decisions to accept somewhat greater risk by fielding systems that are less well-proven.

In this context, the thrust of the Acquisition Improvement Program is twofold: (1) To plan and protect adequate resources for T&E hardware so that it will be unnecessary to accept appreciably increased risks in foreshortened programs, and (2) to place more emphasis on those elements of T&E that address readiness. The following paragraphs elaborate on these themes. For additional background, you are referred to Action 12 and Action 31 (Issue H) in the April 30, 1981, Deputy Secretary of Defense memorandum, and to the March 6, 1982,

DEPSECDEF memorandum on Action 12.[8]

FRONT-END FUNDING FOR TEST HARDWARE

Action 12 spells out the requirement for front-end funding for test hardware as follows: "Provide sufficient test hardware to meet the subsystem, system and software engineers' needs to properly engineer and test development of the end item hardware using parallel testing to reduce overall schedule time." The responsibility for implementing this action lies squarely on the program manager's shoulders. In addition, the Deputy Secretary of Defense, in his March 6, 1982, memorandum, directed "the Under Secretary of Defense for Research and Engineering to have the Director, Defense Test and Evaluation, monitor our progress on this action item, and include in his actions on SCPs [System Concept Papers], DCPs [Decision Coordinating Papers], Test and Evaluation Master Plans, PPBS documentation, and in his assessments to me [DEPSECDEF] on weapon system acquisition, an evaluation of the adequacy of test hardware planned for each development program."

The Acquisition Improvement Program thus puts increased emphasis on concurrent activities, to include concurrent development and testing, and concurrent development testing and operational testing.

The Army, for example, traditionally has performed overlapping (concurrent) development testing (DT) and operational testing (OT). There is a good reason for this: It permits a more expedient development program that leads to an earlier production initiation. It has been difficult in the past to complete all the requirements for DT prior to the scheduled production date, particularly durability testing, electronic warfare testing, and climatic testing. This has led to an earlier initiation of development testing. Additionally, some data from DT is required prior to the start of OT in order to obtain both a safety release and the operational test readiness statement (OTRS). The safety release stipulates that the equipment is suitable for troop operation and poses no major safety threats, such as a chassis that is not electrically grounded. The operational test readiness statement has a larger scope and warrants that the troops, facilities, budget, and hardware resources are sufficient to carry out the operational test to meet the objectives stipulated by the user's representative (TRADOC).

It is important to distinguish between concurrent development/operational testing and combined development/operational testing. Concurrent DT/OT occurs when the tests are conducted in a parallel fashion, usually at different test locations with different prototype equipment. Combined development/operational testing, on the other hand, occurs when the same prototype equipment is subject to both development test and operational test stimuli. Combined development and operational tests are rarely recommended because the integrity of the

8. "Front-End Funding for Test Hardware," DEPSECDEF Memorandum for the Secretaries of the Military Departments, March 6, 1982.

results tends to be diminished. It is diminished because the system is seldom stressed to its ultimate performance capabilities during typical operational test scenarios, (although its ruggedness may be stressed to the limits during some modes of operational testing).

TEST, ANALYZE, AND FIX

Actions 12 and 31 also focus attention on the iterative test, analyze, and fix (TAAF) methodology. Of course, every development program includes numerous test-fix-test cycles; however, this methodology can be extended to aid in the early maturation of technology and to improve the supportability of fielded systems.

The joint Navy-Air Force Advanced Medium Range Air-to-Air Missile (AMRAAM) program will incorporate a formal, 1-year TAAF program beginning in mid-calendar year 1984. A total of seven missiles will be dedicated to this program. During the 18,000 hours of test time accumulated, both all-up rounds and subassemblies will be tested. The program will be conducted by the contractor using dedicated assets and facilities both at the contractor's Tucson, Ariz., plant and at the Pacific Missile Test Center, Point Mugu, Calif. For the most part, the government will maintain a "hands off" position in order to maximize contractor initiative in identifying and correcting design deficiencies.

The Navy's F/A-18 program also incorporates a funded TAAF program. As in the case of the AMRAAM program, the F/A-18 TAAF employs an operational mission environment and a closed-loop design fix for each failure.

COMBINED ENVIRONMENTAL RELIABILITY TEST (CERT)

From the reliability and maintainability perspective, it is important to conduct tests that simulate to the greatest degree possible the experiences that will be encountered in the field. Of all test methodologies developed to date, the combined environmental reliability test has been shown to yield the best correlation with actual experience. For this reason, CERT is a particularly cost-effective methodology.

As the name implies, CERT involves the simultaneous application of two or more environmental stimuli such as altitude, temperature, and vibration. Action 12 makes explicit reference to CERT and notes that one needs to begin combined environmental tests of subsystems and follow these with similiar tests of the entire system.

CERT facilities can be used for a variety of tests such as test, analyze and fix (discussed above), mission profile testing, etc. Indeed, the AMRAAM TAAF program will be conducted in CERT facilities, as will the follow-on reliability verification test (RVT) at the Pacific Missile Test Center. The combined environment will include random accoustic vibration, temperature cycling, and on-off cycling.

As of this writing, 21 companies have CERT facilities, convincing evidence that CERT has come of age. For additional information, see the Proceedings of the DOD Combined Environmental Reliability Test (CERT) Workshop, which was held in Atlanta in June of 1981. The March/April 1982 issue of *The Journal of Environmental Sciences* summarizes the activities of this workshop.[9]

TEST AND EVALUATION OF SUPPORTABILITY

The ultimate "combined environmental, reliability test" is operation and maintenance of the system by the user. The thrust of Actions 12 and 31 is to initiate this type of testing as early as possible in the program, using concurrent development and operational testing if necessary. The objective is not only to mature the technology, but also to gain realistic insights into sparing, maintenance manpower, maintenance skill level, and similar requirements.

One final note: Regardless of the diligence with which we attempt to make operational tests as realistic as possible, no test can be completely representative of a real operational environment. For this reason, the program manager must be prepared to supplement each test with appropriate analytical tasks that fill in the voids.

QUALITY

Once we have designed reliability into our system, it is incumbent on us to assure that the reliability inherent in the design is preserved during the manufacturing process. In a recent presentation at the Defense Systems Management College, Mr. Willoughby noted that the problems encountered during manufacturing of electronic systems are about equally divided between parts and workmanship. He said the cost of removing a faulty part from a circuit board may be from $50 to $10,000, depending on the complexity of the system. It is clear in this context that discovery of faulty parts before they are installed is a worthwhile goal. To this end, the Navy has defined a comprehensive screening program using two techniques: random vibration (6g RMS) and thermal cycling.[10]

In many respects, the problem of improving the quality of workmanship is more difficult; in essence, the solution lies in a commitment to quality workmanship at all levels in the manufacturing organization.

Regardless of the source of a defect, rework is often the source of even further difficulties. Especially in the case of electronic circuits, the replacement of electronic components frequently leads to introduction of stress risers (as the result of mechanical and thermal stresses applied during the rework process). Although the reworked part may pass the functional test at the manufacturing facility, the stress risers often cause premature failure in the field (fracture of component

9. "Department of Defense CERT Workshop, Working Group Summaries," *The Journal of Environmental Sciences*, Vol. 25, No. 2, pp. 25–30. (March/April 1982).
10. NAVMAT P-9492, "Navy Manufacturing Screening Program," May 1979.

leads, delamination of multi-layer circuit boards, and similar failures). For this reason, program managers must be especially conscious of rework of electronic assemblies and take advantage of special techniques such as random vibration testing and thermal cycling to weed out those assemblies with inherent potential for early failure.

Product Improvement

Although it is clearly desirable to design reliability into a system "up-front," one should not ignore the improvements that can be implemented after fielding.

PRE-PLANNED PRODUCT IMPROVEMENT (P^3I)

This is an especially effective instrument because it invokes an up-front commitment to improve the system and provides the interfaces necessary to facilitate incorporation of the improvement (see the paper on P^3I elsewhere in this issue[11]). Consider, for example, the F-101-GE-102 engine mentioned earlier. Two advanced materials have been selected for development as replacements for baseline materials used in the hot section of the engine: Powdered Rene-95 is being developed as a replacement for Inconel 718 in the high pressure turbine disc; and Monocrystal Rene-N4 is being developed as a replacement for directionally solidified Rene-80H in high-pressure and low-pressure turbine blades. Under current plans, these new materials will be introduced into production engines partway through the production run. A key objective of this P^3I program is to increase the life of turbine parts and thereby reduce engine life-cycle costs by reducing spare-parts requirements, and turbine overhaul and repair requirements. Because the components made from these advanced materials will require less cooling airflow, the specific fuel consumption of the engine will be improved, thus lowering the fuel costs for the B-1B fleet. (Note that since blades are normally replaced on a periodic basis, the requisite interfaces already exist.) One word of caution: Because P^3I involves development and, ultimately, the fielding of two different components for the same function, additional logistics complexity will be encountered—at least during the transitional period. It is therefore incumbent upon the PM to evaluate the trade-offs involving the improved reliability/supportability and the added logistics burden.

COMPONENT IMPROVEMENT PROGRAM (CIP)

Equally as important as P^3I programs are the product improvement programs triggered by events not anticipated by design engineers. Although the designer doesn't know "where the lightning will strike," he is sure "it will strike somewhere." Accordingly, he plans in advance for a component improvement program that will resolve technical, operation, and support problems experienced by the user in service.

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11. Lieutenant Colonel Garcia E. Morrow, USA, and Dr. Jules J. Bellaschi, "A Cultural Change: Pre-Planned Product Improvement."

The F-101-GE-102 component improvement program is typical. Planning for this program, including an initial 5-year budget estimate, was started in 1981. The CIP is planned for start in October 1983, shortly after delivery of the first production engine, and to yield initial results (engineering change proposals) in 1984.

PRODUCTIVITY, RELIABILITY, AVAILABILITY, MAINTAINABILITY (PRAM) PROGRAM

The PRAM program was established in 1975 to combat the Air Force's rapidly rising operation and maintenance costs. Since its inception, $60 million have been invested in the program and yielded a net life-cycle cost avoidance of $1.4 billion. The following example illustrates the types of problems solved by PRAM: C-130 foward engine mounts were failing after only 1,650 hours of service. Through redesign and use of a more heat-resistant rubber compound, the service life of the mount was doubled. Savings on this project are estimated to be $657,000 after a PRAM investment of $17,552.

Industry Involvement

The involvement of industry is vitally important to assure maximum return on dollars invested in reliability and maintainability. The following two actions address this point.

ACTION 16—CONTRACTOR INCENTIVES TO IMPROVE RELIABILITY AND SUPPORT

As noted in another paper in this issue, there are a variety of tools for improving reliability and support at the fingertips of the program manager, and it is incumbent on the PM to take advantage of each one: source selection criteria, contractual incentives, award fees, reliability improvement warranties, guarantees, and so forth.[12]

The storage mean time between failure guarantee for the AMRAAM is an interesting case in point. Beginning in late 1986, 100 missiles will be put in open storage for 2 years. If the reliability proves to be less than 0.86, the contractor will submit "no cost" engineering change proposals (ECPs) to correct the deficiencies. The government will pay for the retrofits if the reliability is between 0.81 and 0.86. If the reliability is less than 0.81, the contractor will pay for the retrofit. If, on the other hand, the reliability is between 0.86 and 0.94, the contractor will win a portion of the available incentive. Finally, if the reliability is above 0.94, the contractor will be awarded the entire $10 million incentive.

One of the most commonly heard complaints, both in the industrial sector and in the government, is that the initiatives instituted by the government are taken advantage of by the prime contractors but not passed on to the sub-tier contractors. Thus, the government reaps only a fraction of the available benefits.

12. Dr. John P. Solomond, "Contractor Incentives to Improve Reliability and Support."

In this context, it is instructive to examine one of the special contract provisions established in the acquisition strategy for the Air Force's C-17 program, specifically the provision dealing with vendor warranties. As proposed, the contractor would have made a reasonable effort to:

—Obtain written warranties with vendors;
—Advise the government as to the character and extent of sub-warranties;
—Obtain agreement from vendors that such warranties would be transferrable to the government upon completion of interim contractor support; and
—Administer and enforce vendor warranties during interim contractor support.

The government, in return, would have contracted to pay an award fee for contractor performance in vendor warranty administration based on the extent the contractor saved the government expense. This technique should be equally suitable for incentivizing the pass-down of other types of initiatives.

As an aid to help the program manager develop appropriate contractual incentives, the Air Force has prepared the joint AFSC/AFLC *Product Performance Agreement Guide*. This guide focuses on methods of motivating the contractor to deliver items that perform as advertised, and contains 23 different types of agreements that may be appropriate for use in weapon-system contracts.

ACTION 32—COMPETITION

Competition is another tool available to the program manager. Although competition is usually interpreted as "price competition," it can also be used to stimulate the contractors to pay particular attention to other important elements of a weapon system program, such as reliability and maintainability.[13] Note, however, that because competition, like P³I, could (although it won't necessarily) lead to the development and fielding of two components for the same function, the program manager must carefully weigh the benefits and costs of competition, and execute an acquisition strategy in which any additional logistic complexities are balanced by offsetting benefits.

INDEPENDENT RESEARCH AND DEVELOPMENT (IR&D)

Earlier this year, the Department of Defense completed a brief analysis of the commitment of independent research and development (IR&D) resources to weapon system readiness and support. The analysis revealed that only a small portion (about 2 percent) of IR&D man-years is directly allocated to logistics and logistic-related activities. This fraction seems disproportionately small in view of the fact noted earlier that more than 50 percent of the life-cyle cost of a system is logistics oriented.

With this information as a background, the Under Secretary of Defense for Research and Engineering signed a memorandum to the appropriate assistant secretaries of the military departments asking each service to urge its IR&D con-

13. See John C. McKeown, "Increasing Competition in the Acquisition Process."

tractors to expand their activities in logistic R&D.[14] In his memorandum, Dr. Richard D. DeLauer highlighted the following areas because of their potentially enormous payoff: automated diagnostics, high mission-critical reliabilities, low-cost maintenance training devices, long-life materials and components, automatic or electronic documentation production and distribution, maintenance-free subsystems, two-level maintenance systems, and logistic control and management subsystems. The ultimate objective is, of course, to begin putting some of this technology "on the shelf" so that it will be available when needed for new systems.

Management Emphasis

When the working group on readiness and support submitted its report to the Acquisition Improvement Steering Group in March 1981, it noted that there are several efficiencies that can be employed selectively to get a better return for support resources. These efficiencies are largely in the arena of planning and programming, and emphasize the importance of a carefully thought-out strategy, and of the discipline to stick to our plans.

LOGISTIC ANALYSIS

The analysis of logistic requirements is a discipline with a venerable tradition. The current standard is MIL-STD-1388, dated October 15, 1973, which defines the formal logistic support analysis (LSA). As noted in the standard, the LSA is the "composite of systematic actions taken to identify, define, analyze, quantify and process logistic support requirements."[15]

With the adoption of the Acquisition Improvement Program, even greater emphasis has been placed on logistic analysis; in support of this, MIL-STD-1388 is being revised to appropriately reflect the key precepts and recommendations of the Acquisition Improvement Program. The new standard, currently in draft form, will emphasize (in addition to the traditional elements of the LSA):

—The importance of establishing the readiness objective, strategy, goals and thresholds very early in the program;

—The value of identifying and capitalizing on technological opportunities to reduce the support, manpower, personnel, and training requirements for the system (designing for reliability and supportability);

—The value of a post-production support analysis;

—The importance of dedicating test and evaluation resources to assess the achievement of the specified readiness requirements.

In short, this new standard, together with its companion, MIL-STD-XXX, "Weapon System and Equipment Support Analysis Documentation," will be the

14. USDRE Memorandum, "Increased IR&D for Improved Weapon System Readiness and Support," March 1, 1982.

15. MIL-STD-1388-1, "Logistic Support Analysis," October 15, 1973, paragraph 5.1.1.

principal guidance for conducting and documenting support analyses as part of an integrated logistic support program for future systems.

SPARES

The provisioning of spares is a tremendous concern because relatively small changes in operational availability require relatively large outlays for spares. Traditionally, provisioning of spares has been based on individual item demand, i.e., on field experience with the item (or one similar to it). These methods, while reasonably effective, fail to take into consideration the overall operational availability requirement of the system. Recent experience with provisioning optimization models indicates that more cost-effective provisioning of spares can be achieved if one considered the overall readiness goals of the system instead of the isolated experience of each individual item. Moreover, these optimization models provide, for the first time, not only the relationship between operational availability and reliability and maintainability parameters (such as MTBF), but also the relationship between operational availability and the required investment in spares.

In their August 1981 paper, referenced earlier, McGrath and Henry described the application of the comprehensive aircraft support effectiveness evaluation (CASEE) model to the evaluation of the support requirements for one F/A-18 squadron deployed aboard an aircraft carrier operating under typical peacetime and wartime scenarios. Illustrative results are shown in Figures 6 and 7. Note that this type of analysis aids the program manager in assessing whether there is need for further reliability improvement and whether the proposed spares budget is adequate.

In some cases, even the most sophisticated model fails to yield acceptable results, and the program manager must resort to extraordinary measures. The SURTASS sparing study is illustrative. Because SURTASS ships operate independently at sea, a reasonably stringent operational availability (0.85) has been established for the total system. When the sparing requirements were computed using the Fleet Logistics Suppport Improvement Program (FLSIP) methodology, it was found that the predicted operational availability was 0.70 to 0.75, far short of the requirement.[16] Further analysis showed that eight of the 79 shipboard equipments would have significantly improved contributions to the overall operational availability if supply support for them were improved. Accordingly, a unique SURTASS allocation model was developed for these eight equipments, and the FLSIP methodology was employed for the remainder. The net result was achievement of the required operational availability within an acceptable increase in the cost of spares.

16. FLSIP provides 90 percent assurance against a stockout for items having at least four demands per year, and provides a numeric stockage objective quantity for additional items expected to fail at least once in 4 years.

FIGURE 6
Sorties Achieved vs. MFHBF

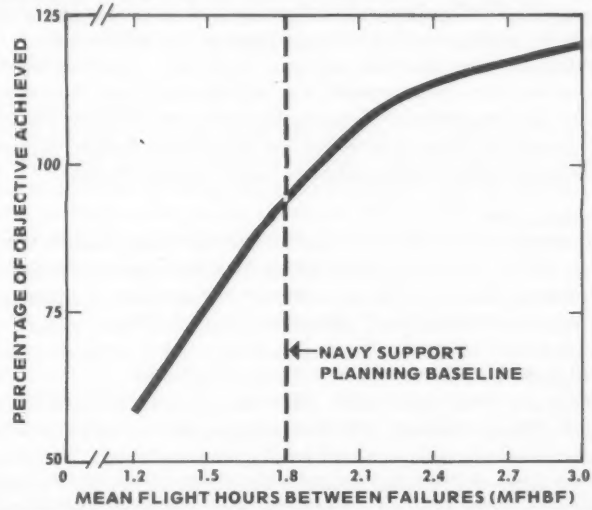
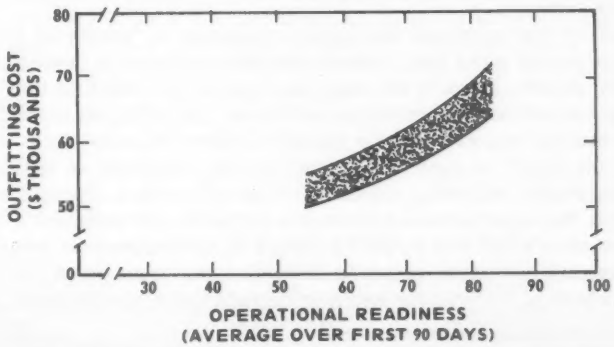


FIGURE 7
F/A-18 Carrier Outfitting Cost vs. Operational Readiness



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The manufacturing of spares is another arena in which efficiencies can be sought. In many cases, procurement efficiencies can be achieved if spares are manufactured on the same production lines as the original equipment. The advantages of this concept, called spares acquisition integrated with production (SAIP), are apparent: The spares can be procured in more economical lot sizes, and the form, fit, and function of the spare parts can be guaranteed.

One additional item deserves mention. With the relaxation of statutory restrictions on multiyear procurement, it is appropriate to use this vehicle more frequently for the procurement of spares; budgeting for the cancellation ceiling should not present a major impediment for these procurements because of its relatively small size (unlike the situation in major weapon systems).[17]

COMMON COMPONENTS

Among the many trade-offs the program manager must evaluate throughout the life cycle of the weapon system, decisions with respect to common components are among the most difficult. Although the selection of a common component usually simplifies support, this action often introduces weight, volume, and/or performance penalties. The responsibility of the program manager to carefully weigh the alternatives needs no further emphasis.

The F/A-18 is a good case in point. The basic aircraft is identical for both the fighter and the attack missions, and one configuration can be converted to the other in a matter of minutes by changing the pylons and stores. This was not an accident. By a series of conscious decisions during development, the temptation to develop two slightly different aircraft was repeatedly rejected. Consider the landing gear, for example: The fighter version carries lighter stores and does not need a landing gear that is as heavy as that needed for the A-18; the opportunity to save a few pounds existed and was passed over. This decision, and others like it, simplified the logistic support requirements for this Navy and Marine asset.

CONRACTOR SUPPORT

Because of the traditional difficulties encountered in "getting up to speed" with a new system in the field, there is increasing sentiment in favor of interim contractor support. There is no magic formula for the length of time during which interim contractor support is advantageous. As in the case of the F/A-18, which is making extensive use of a phased transition from contractor to Navy support, the length of time will depend on the complexity of the required maintenance tasks, and on the skills available at each echelon. During the transition period, the organizational maintenance personnel gain proficiency, and the contractor plays a key role in the maturation of the maintenance and support design concepts, equipment, and procedures. One may argue that if the contractor knows he must live with the system in the field for an interim period, he will

17. See Dr. Abraham Singer, "Enhanced MYP for Improving Weapon System Acquisition."

pay more attention to designing for maintenance and support. The other side of this is the danger that, in anticipation of solving maintenance and support problems after fielding, the contractor will pay too little attention to this aspect early in the program; the program manager must work hard to avoid this pitfall. In fact, Action 31 explicitly charges the program manager with giving increased attention to the front-end of the program and avoiding the necessity of an eleventh-hour catch-up.

RESOURCES FOR SUPPORT

The management of resources for support is complicated by two circumstances. First, the budget is reviewed by appropriation category, and several appropriation accounts are involved in the fielding of weapon systems: R&D, procurement, military construction, operation and maintenance, and military personnel. Second, there are several weapon-support activities that are controlled by service organizations that are *not* responsible to the program manager (see Figure 8). Consequently, the program manager has neither complete visibility of, nor control over, the decisions and resources that influence the readiness of his system.

Concern over this situation was expressed in the 1981 Defense Science Board Summer Study on operational readiness with high-performance systems. Similar concern was echoed by the Deputy Secretary of Defense in his April 30, 1981, memorandum, and served as the basis for Action 30 (Issue G), "Program Manager Control over Logistics and Support Resources." The April 30, 1981, memorandum gave three key requirements.

—That the services submit with the program objective memorandum (POM) their resource requirements and readiness objectives, by weapon system, for

FIGURE 8
Weapon Support Activities

	ARMY	NAVY	AIR FORCE
SPARES FOR SITE ACTIVATIONS	MATERIEL READINESS COMMAND (MRC), (ICP)	PM (1-2 YEARS), INVENTORY CONTROL POINTS (ICP)	AFLC
TEST EQUIP SPECIAL- COMMON-	 PM/PM TEST EQUIP MRC	 PM NAVELEX	 PM AFLC
TRAINING EQUIP- FACILITIES- OPERATION- SUSTAINED-	 PM/PM TRADE COE TRADOC/MRC/MACOM TRADOC	 PM PM TRAINING COMMAND TRAINING COMMAND	 PM ATC ATC ATC
DEPOT EQUIP SPEC- COMM- SPARES- OPERATIONS-	 PM DEPOT SYSTEMS CMD (DESCOM) MRC DESCOM	 PM NAVELEX ICP NAVMATCMD(NMC)	 PM AFLC AFLC AFLC
CONTRACTOR SUPPORT	MRC	PM/ICP	AFLC
SUPPORT FACILITIES	CORPS OF ENGINEERS (COE)	NMC/FLEET	USER
MANPOWER REQUIREMENTS	DEPT OF ARMY	CHIEF OF NAVAL OPERATIONS	USER

systems entering or in early production.
—That the services develop internal procedures to give the program manager more control of support resources, funding, and execution.
—That OSD conduct a single review of support associated with individual systems.

On June 1, 1981, the Assistant Secretary of Defense, Comptroller (ASD(C)) and the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics (ASD(MRA&L)) jointly signed a tasking memorandum to the services.[18] In response, the services proposed an implementation plan and recommended that the following six systems serve as test cases: M-1 Tank, Advanced Attack Helicopter, F/A-18, AEGIS, Ground Launched Cruise Missile, and B-1B. The OSD concurred with the plan on 18 September 1981.[19]

The vehicle for implementation was a budget-matching technique whereby the requirement for logistic support resources was compared to the amount funded.

The trial process had three key steps. (1) Presentation by the program manager. This presentation to OSD was scheduled about a week after service budget submission. It included the support schedule and readiness objectives, a summary of the weapon system support funding profile, and an analysis of the support requirements as a function of the schedule and the readiness objectives. (2) OSD POM/budget review. During the course of the normal OSD reviews, the data submitted by the program manager were reviewed to identify and, where possible, correct support-funding shortfalls. In addition, the data were updated to reflect program/budget decisions (PBDs). (3) Reporting to DRB. At the conclusion of the OSD budget review cycle, OASD(C) and OASD(MRA&L) prepared a final edition of the data submitted by the program manager and forwarded it to the DRB principals with a copy to the program manager.

The trial procedure is still being evaluated. The first results were made available by the ASD(MRA&L) on March 4, 1982.[20] There has aleady been one benefit in that, with the new procedure as a vehicle, some shortfalls have been identified and resolved. An expanded program is anticipated for the FY 84 POM cycle. In the long term, a procedure similar to the trial process probably will be adopted; the briefings by the program managers likely will be replaced with data submissions.

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18. Joint ASD(C) and ASD(MRA&L) Memorandum, "Program Manager Control Over Logistic Support Resources," June 1, 1981.
19. Joint ASD(C) and ASD(MRA&L) Memorandum, "Improved Management of Weapon System Support Finding," September 1981.
20. ASD(MRA&L) Memorandum, "Improved Management of Initial Support Funding for Major Systems (Carlucci Initiatives Number 30), March 4, 1982.

POST-PRODUCTION MILESTONE REVIEW

The concept of a post-production milestone review is introduced by way of the figure used to illustrate the various options in Action 24 (Issue A). Although this review is not discussed in the April 30, 1981, memorandum, it is described in detail in the March 30, 1981, steering group report.

As conceived in the steering group report, the review would be conducted by the service 2–3 years after IOC (on a schedule established at the production milestone). It would review follow-on test results and early field experience, assess operational effectiveness and suitability, and compare cost, performance and operational readiness against the goals and thresholds established (in the Secretary of Defense decision memorandum (SDDM)) for the program. The review would serve as a forum both for review of plans to improve the hardware and its support, and for review of any pre-planned product improvement efforts. Such a review would also uncover numerous "lessons learned" that could be fed back into other systems.

Preparation for the Future

So far we have focused on programs already under way. However, there is an important component of these Acquisition Improvement Program actions that focuses on the future—on programs that have not yet been formally initiated.

MISSION AREA LOGISTICS ANALYSIS

Emphasis on planning pervades the entire DOD Acquisition Improvement Program, but long-range plans must be thoroughly grounded in a careful front-end analysis. As a case in point, consider the 1979 Sea Based Air Logistics Study performed by the Naval Air Systems Command.[21] This study was one part of the Chief of Naval Operations (CNO) Sea Based Air Master Study, which is intended to determine the characteristics of the U.S. Navy's sea based air forces 20 years hence. The logistics study was wide ranging; it assessed the impact of new aircraft technologies on support, examined the effect of sea state and platform motion (particularly roll) on the effectiveness of maintenance personnel, studied the economy of scale associated with creating minimum aircraft complements of 6 to 8 aircraft for logistics efficiency, took note of the projected reduction of skilled manpower over the next 20 years, and developed a set of recommendations that took these and other factors into consideration. A study of this type not only provides guidance in terms of what is or is not practical, but also indicates major directions for future RDT&E if the operatonal concepts are adopted.

21. AIR-4105-B, Naval Air Systems Command, "Sea Based Air Logistics Study, Final Report, December 1979.

MANPOWER AND SKILLS LEVEL

As noted earlier, the acquisition and retention of skilled maintenance and support personnel is a tough problem and is expected to become even more difficult. The following extract from the March 30, 1981, steering group report illustrates the point.

> Retention patterns vary markedly among the Services, among occupations with a Service, and in some cases between successive years. Overall the first-term reenlistment rates for electrical and mechanical maintenance occupations during FY 77-80 have ranged from 17 percent to 43 percent, that average being roughly 36 percent. The patterns for career force reenlistment—that is for experienced personnel—have ranged from 46 percent to 86 percent, the average being roughly 67 percent.

The steering group noted that these rates are "regarded as inadequate . . . to maintain the capability needed to fix our weapons.[22]

Action 16 directly addresses this situation and recommends in part that improvements "be developed in the method of projecting critical maintenance manpower skill limitations and translating these into design constraints and objectives for inclusion in RFPs and specifications." This is the crucial first step—providing a baseline for the design of hardware and development of procedures. The overall objective is to field weapon systems that are compatible with the projected manpower and skill limitations.

Although we are a long way from being able to predict the relationship between weapon system design parameters and the demographics and skills of the personnel who must repair and maintain these systems, we are nevertheless making significant progress, and analytical tools that will help us bridge this gap are emerging. Typical is the HARDMAN methodology, developed by the Navy to assist in estimating manpower, personnel, and training requirements for new weapon systems (principally aircraft). The heart of the HARDMAN methodology is a comparability analysis in which the conceptual system is compared and contrasted with a reference system consisting of a set of current equipments that can accomplish the same objective. By studying the differences between the reference system (for which manpower, personnel and training (MP&T) resources can be estimated reasonably accurately) and the conceptual system, one can make good estimates of the MP&T requirements for the conceptual system. Moreover, one can then test these requirements against the projected availability of these resources and make decisions (either in the design arena or in the MP&T arena) that will avoid any "disconnects."

22. "Improving the Defense Acquisition System and Reducing System Cost," DOD Steering Group Report, Office of the Secretary of Defense, March 30, 1981.

The HARDMAN methodology has been applied to the Army's enhanced self-propelled artillery weapon system (ESPAWS), a self-propelled 155 mm howitzer intended to replace the M109 howitzer as the principal indirect fire-support system at division level and below. This work was reported recently in a paper by Thomas E. Mannle, Jr.[23] At the conclusion of Phase I of this work, the methodology had yielded a variety of valuable outputs, including quantitative manpower requirements, qualitative organizational maintenance manpower requirements (by MOS), training requirements (including the needs for modified and additional courses), and instructor requirements for system-specific maintenance and operator courses. One of the principal lessons learned from this work is the tremendous sensitivity of the analysis to a quantitative description of the scenario in which the system will be used. Obviously, a study such as this has its greatest impact early in the development process when design changes to accommodate the findings of the study can be made more easily.

In addition to the evolution of new analytical methodologies (such as HARDMAN), we are also, as noted earlier, seeing the development of design features specifically focused on the objective of making repair and maintenance easier. The current thrust to use more automated test equipment (ATE) and built-in test is illustrative. The movement to simplify maintenance and repair procedures is similarly motivated. Increasingly, emphasis is being placed on plug-in replacement units—both on the line and in the shops—and more and more, failed units are being designed for return to the manufacturer or a contractor facility for repair.

In the interim, as we progress through this transitional period in which maintenance concepts and strategies are in a state of flux, it may be necessary to employ service personnel in the most critical areas to maintain our combat capability, and use contractor support to augment our indigeneous capabilities.

STANDARD SYSTEMS

The advantages and challenges associated with using standard operational and support systems have been described by Colonel Walker Larimer elsewhere in this issue in conjunction with the discussion of Action 21.[24] He notes the principal thrust of Action 21 is preparation for the future, requiring the identification and development of standard subsystems and support systems (and their technology) to meet projected weapon system needs. Let it suffice to note that significant savings can be achieved:

—The costs of developing a new item are avoided.

—The program manager capitalizes on the relatively mature technology of the

23. Thomas E. Mannle, Jr., "Application of the Hardman Methodology to ESPAWS, the Army's Howitzer of the Future." Mr. Mannle is ESPAWS Program Manager, *Dynamics* Research Corporation, Wilmington, Mass.

24. Colonel Walker A. Larimer, USAF, "Action 21: Standard Operation and Support Systems."

previously developed item.
—Logistics complexity is avoided by using common items and spares.

Noteworthy standardization has already been made by the services; examples worthy of note include use of the F-16 radar in the Army's DIVAD system, use of an F-16 radar derivative in the B-1B bomber, and Air Force selection of the Navy APX-100 LFF system as the standard for future Air Force applications.

LOGISTIC RESEARCH AND DEVELOPMENT

The second part of Action 21, "Develop and Use Standard Operational and Support Systems," recommends that OSD and the services "support a program of weapon support R&D to put diagnostic, repair, and logistic technology on the shelf." This recommendation is responsive to a need that has been felt and articulated in many circles for over a decade.

Many kinds of research and development are included under this umbrella.
—Modeling the logistic process
—Streamlining the logistic structure
—Developing systems with drastically reduced support requirements (logistic tails)
—Developing systems inherently easier to repair and maintain
—Built-in test and automatic test equipment
—Material and components inherently more reliable, with lesser requirements for maintenance
—Improving non-destructive inspection (NDI) equipment and techniques
—Rapid and effective field-repair techniques and materials
—More productive industrial repair and rework facilities and equipment.

As an initiative, logistic R&D actually predates the Acquisition Improvement Program. The services were formally tasked to submit ideas in this area by a memorandum signed jointly by Dr. Walter LaBerge and Dr. Robert Pirie in the fall of 1980.[25]

Each service is addressing this initiative. The Air Force, for example, has identified money in the FY 83 POM and requested reprogramming of FY 82 monies to get started. On March 30, 1982, the DOD joined with industry to host a joint symposium on logistic research and development. Momentum is gathering; the payoff is tremendous.

Summary

As we reflect on the material presented in this paper, it is apparent (1) that the Office of the Secretary of Defense is intent on significantly enhancing the

25. OSD Memorandum, "Research and Development for Improvement of Weapon Support," jointly signed by the Principal Deputy Under Secretary of Defense for Research and Engineering and the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), September 3, 1980.

readiness of fielded systems and (2) that there are numerous opportunities and precedents for actions by the program manager.

A variety of DOD directives and instructions will be issued to detail the initiatives set in motion by the DOD Acquisition Improvement Program. The DODD 5000.1 was signed on March 29, 1982, and work on DODI 5000.2 is drawing to a close. Based on these two cornerstones, DODD 5000.3, DODD 5000.39 and DODD 5000.40 will be issued later. Meanwhile, numerous OSD memoranda have been issued to get the process under way. The program manager can look to these memoranda for elaboration on the fundamental intent of the Acquisition Improvement Program.

It should be quite clear, however, that no directive, instruction, regulation or memorandum is an adequate substitute for a good idea and the initiative to put it in motion. This is the challenge to you, the program manager. At stake is the readiness of our armed forces—present and future. ‖

TABLE I
Readiness Requirements (R&M, Support & Personnel)

MILESTONE		
I	(1)	REQUIREMENT VALIDATION BASED ON CONCEPTS, COSTS, SCHEDULE, READINESS OBJECTIVES, AFFORDABILITY
	(2)	THRESHOLDS ESTABLISHED FOR READINESS
II	(1)	VALIDATE LOW-READINESS RISK BEFORE PROCEEDING INTO FSD
	(2)	IDENTIFY R&M TEST RESULTS TO DATE AND THE QUANTITATIVE IMPACT OF DIFFERENCES IN RESOURCE REQUIREMENTS SUCH AS PERSONNEL, SPARES, AND DEPOT MAINTENANCE, TO MEET READINESS OBJECTIVES.
	(3)	ESTIMATE DEFICIENCIES OF CURRENT AND PLANNED SUPPORT SYSTEMS TO MEET LOGISTIC OBJECTIVES FOR THE SYSTEM, SUCH AS RESUPPLY TIME, MAINTENANCE TURN-AROUND, AND AUTOMATIC TEST EQUIPMENT PRODUCTION RATE AND CAPACITY.
	(4)	IDENTIFY PLANS AND FUNDING FOR INTERIM CONTRACTOR SUPPORT AND ANY SUBSYSTEMS CONSIDERED FOR LONG-TERM CONTRACTOR SUPPORT AND THE ANALYSIS LEADING TO CONTRACTOR SUPPORT DECISIONS.
	(5)	EXPLAIN BRIEFLY SIGNIFICANT MANPOWER DIFFERENCES IN NUMBERS AND SKILLS LEVELS IN COMPARISON WITH A CURRENT COMPARABLE (REFERENCE) SYSTEM, CONSIDERING DESIGN AND SUPPORT CONCEPTS, AND EMPLOYMENT OBJECTIVE.
	(6)	IDENTIFY PROJECTED SHORTFALLS IN MANPOWER OCCUPATIONAL SPECIALTIES REQUIRED FOR THE NEW SYSTEM IN CRITICAL CAREER FIELDS. IDENTIFY NEW OCCUPATIONS THAT MAY BE REQUIRED. IF SHORTAGES EXIST, EXPLAIN HOW REQUIRED MANNING WILL BE ATTAINED.
	(7)	SUMMARIZE SIGNIFICANT DIFFERENCES IN TRAINING REQUIREMENTS AND APPROACH FOR THE NEW SYSTEM VERSUS A COMPARABLE REFERENCE SYSTEM. IDENTIFY TRAINING EQUIPMENT DEVELOPMENT AND ANTICIPATED SAVINGS FROM USE OF SIMULATORS OR OTHER TRAINING DEVICES FOR OPERATIONS, MAINTENANCE, AND SUPPORT PERSONNEL.
	(8)	DEFINE EACH R&M PARAMETER THAT APPLIES TO THE SYSTEM PROPOSED IN THE DCP.
	(9)	IDENTIFY POL REQUIREMENT AND ANY ADDITIONAL RESOURCES OR FACILITIES REQUIRED TO SUPPLY POL FOR THE NEW SYSTEM.
III (IF A SECRETARY OF DEFENSE DECISION IS REQUIRED)		
	(1)	UPDATE MILESTONE II IPS, PARTS (1), (2), (3), (4) AND (5).
	(2)	SUMMARIZE PLANS AND ADDITIONAL RESOURCES REQUIRED TO TRAIN THE INITIAL COMPONENT OF OPERATING AND SUPPORT PERSONNEL FOR UNIT CONVERSION TO FIELDED SYSTEMS. SUMMARIZE PLANS FOR TRAINING RESERVE COMPONENT PERSONNEL WHOSE MISSION REQUIRES OPERATION OR SUPPORT OF THE SYSTEM.
	(3)	REFERENCE PLANS FOR VALIDATION OF PROFICIENCY CRITERIA AND PERSONNEL PERFORMANCE.

Enhancing Productivity Through Increased Capital Investment

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Dr. Andrew P. Mosier

Productivity is increasingly recognized as one of our critical national issues. The House Committee on Armed Services tells us why.

> While the United States leads the world in productivity, the United States is *dead* last in productivity improvements among all industrialized nations of the world.[1]

The national defense implications of this deteriorating situation are ominous. The United States was the highly productive arsenal of democracy in the '40s. Its continuing lead in productivity today stems from the technological advances and capital investments made largely in the '50s and '60s. But this lead may not last much longer. The serious downward trend during the past decade in the rate of investment in productivity-enhancing modernization of U.S. plants, particularly in defense-supporting industries, is well known. If continued, this adverse trend portends a dire future for the United States and the Free World.

On September 17, 1980, the House Committee on Armed Services began intensive hearings on the capability of the U.S. defense industrial base to produce the military equipment needed to ensure the national security. These hearings were continued by a 10-member Defense Industrial Base Panel, which found that "there has been a serious decline in the nation's defense industrial capability that places our national security in jeopardy."[2]

The panel found that defense industry has failed to modernize. As an example, during the past decade, the U.S. aerospace industry invested approximately 2 percent of its sales in new capital assets. The average rate of investment for all U.S. industry during this same period was about 8 percent, and the average rate of investment for all U.S. manufacturing was 4 percent. This lack of investment by a vitally important sector of defense industry has resulted in a situation where much of the equipment is old and inefficient. For example, 60 percent of the metal working equipment used in defense contracts today is more than 20 years old.[3]

In his February 1982 posture statement, the Secretary of Defense told the Congress that "productivity in defense-supporting industries is too low. . . ." He also said that "compared to other business, defense contracting is viewed by business

1. *The Ailing Defense Industrial Base: Unready for Crisis*, Report of the Defense Industrial Base Panel of the Committee of Armed Services, House of Representatives, 96th Congress, 2nd Session, December 31, 1980, Committee Print No. 29: GPO, p. 16.
2. *The Ailing Defense Industrial Base*, Letter of Transmittal, p. III.
3. *The Ailing Defense Industrial Base*, p. 17.

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as less stable, less predictable, and thus less attractive than commercial business."[4] The Secretary is concerned about the adverse impact of both situations on our defense industrial base, and ultimately on our national security.

The purpose of this paper is to report on the actions being taken to reverse the downward trend in the rate of investment in U.S. defense plant modernization. These include the eight different initiatives comprised by Action 5 of the DOD Acquisition Improvement Program (AIP), and eight actions recommended, in March and April 1982, as part of the DOD Industrial Responsiveness Improvement Program (IRIP). These 16 actions from the two programs can be viewed holistically as an integrated program that weaves relevant productivity-enhancing and industrial-preparedness actions into the acquisition process. The ultimate objective of this integrated program is to encourage investment to enhance the productivity of contractors on individual defense acquisition programs, and, in the aggregate, to help increase the productivity and responsiveness of the U.S. defense industrial base to peacetime, surge, and mobilization production requirements.

The sources of the 16 actions and essential background are discussed first to indicate the character and scope of the integrated program. Next, these actions are organized into four major interdependent areas of activity, each of which must be successfully accomplished in order to achieve the overall objective of the program. Each of these major areas and its component actions are then discussed in some detail, including progress to date.

Acquisition Improvement Program Action 5

The DOD Acquisition Improvement Program addresses many different facets of the acquisition process.[5] One of the principal thrusts of the program is to improve productivity on individual contracts and, ultimately, the productivity of all defense contractors. It intends to do this both indirectly and directly. Indirectly, it is being done through such AIP actions as Action 3: "Multiyear Procurement"; Action 4: "Program Stability"; and Action 32: "Increase Competition in the Acquisition Process." Implementation of these and other related AIP actions should create a climate of greater program stability and of effective competition in which companies will vie for defense contracts and more readily make productivity-enhancing capital investments. Productivity should be directly improved through Action 5, with its spectrum of subactions to encourage defense

4. Caspar W. Weinberger, *Annual Report to the Congress: Fiscal Year 1983*, February 8, 1982, p. III-191.

5. U.S. Department of Defense, *Final Report: DOD Acquisition Improvement Task Force*, December 23, 1981. A report on the 32 actions that make up the DOD Acquisition Improvement Program, including a detailed description of what had been accomplished through December 1981, significant barriers to implementation, and specific recommendations to achieve prompt implementation of the 32 actions.

contractors to invest in capital equipment and facilities to enhance productivity.[6]

Action 5: "Encourage Captial Investment to Enhance Productivity," involves eight different subactions, all related to, or implemented by, defense contracts.[7] These subactions include depreciation legislation, return on investment, progress payments, profit policy, economic price adjustment, patents and data rights, manufacturing technology, and excess profits legislation. The Under Secretary of Defense (Research and Engineering) (USDRE), has primary responsibility for implementing these eight subactions, working closely with the General Counsel of the DOD, the Assistant Secretary of Defense (Legislative Affairs), and the service material commands.[8]

Industrial Responsiveness Improvement Program

The eight productivity-enhancement initiatives of Acquisition Improvement Program Action 5 are only part of a larger DOD effort to more effectively integrate contractor productivity and industrial preparedness issues into the acquisition process. On March 2, 1981, when the Deputy Secretary of Defense established the DOD Acquisition Process Working Group, he also stated that another major acquisition issue, industrial preparedness, was being addressed separately. He emphasized that the recommendations of the working group had to be consistent with increasing industrial preparedness.[9] The Acquisition Improvement Program actions described earlier are consistent with this direction.

The industrial preparedness issue was addressed by the DOD Task Force to Improve Industrial Responsiveness (TFIRE), a joint-service team formed on May 20, 1981, by Dr. Richard D. DeLauer, Under Secretary of Defense (Research and Engineering).[10]

In reaching its findings, the TFIRE team used the Improvement Triad from the DOD Action Plan to Improve Industrial Responsiveness as a framework for orienting its efforts. The elements of the triad are the Defense Acquisition Process, Industrial Preparedness, and the National Resource Base of materials, skilled labor, and productivity. The task force recommended 12 actions, each of which addresses one or more elements of the Improvement Triad. Seven of the

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6. Colonel G. Dana Brabson, USAF, "Department of Defense Acquisition Improvement Program," *Concepts*, Autumn 1981, pp. 68-69.

7. *Final Report: DOD Acquisition Improvement Task Force* (Action 5 subactions, pp. 5-1, 5a-1–5h-1).

8. *Ibid.*

9. U.S., DEPSECDEF Memorandum, subject: "Improving the Defense Acquisition System and Reducing System Costs," March 2, 1981. This tasking memorandum, which established the Steering Group and initiated the DOD Acquisition Improvement Program (AIP), is included as Attachment 1 to the *DOD Steering Group Report: Improving the Defense Acquisition System and Reducing System Costs*, March 30, 1981.

10. USDRE Memorandum, subject: "Improving Industrial Responsiveness," May 20, 1981. This tasking memorandum is included as Tab 1, Task Force Charter, of the report of the Task Force to Improve Industrial Responsiveness (TFIRE).

actions aim to integrate industrial base productivity and responsiveness issues into the defense acquisition process.[11]

The Deputy Secretary of Defense emphasized the need for this integration in a DOD policy statement on industrial preparedness on March 6, 1982. He said:

> We must *weave industrial base considerations into the acquisition process,* revitalize industrial preparedness planning, and show industry, through both planning and actions that *industrial preparedness is an integral part of acquisition.* [Emphasis added.][12]

This integration will require major changes by program managers and contracting officers in their acquisition philosophy and program management procedures. It will also require changes in program and procurement planning, Defense Systems Acquisition Review Council (DSARC) reporting, contracting philosophy, and implementation of present profit policy.

The 16th action covered in this paper was a result of a September 2, 1981, memorandum from Dr. DeLauer, which asked the services to place greater emphasis on the DOD manufacturing technology program. When briefed by each service on its program, he became concerned about the lack of a unified DOD policy defining the contracting strategy and use of financial resources necessary to implement it. Accordingly, on February 17, 1982, Dr. DeLauer established a tri-service committee, chaired by the Navy, to prepare a proposed unified DOD policy on "technology modernization."[13] On April 21, 1982, the committee submitted a draft DOD instruction for a DOD productivity enhancement program.[14]

Having identified the immediate origins of the 16 actions, let us consider the background leading up to them.

Essential Background

In early 1975, the DOD sponsored a number of studies related to capital investment in defense business. One, entitled *Profit '76,* found that for several years contractor facility investment in DOD contracts had been considerably lower than in comparable commercial endeavors, even after taking into account government-furnished facilities and equipment.[15] As a result, DOD profit policy on negotiated contracts was revised in 1976, and again in 1980, in an effort to make the facilities investment incentive meaningful in contractor investment decisions.

11. *Summary Report: DOD Task Force to Improve Industrial Responsiveness,* March 1982. (Each recommendation by the TFIRE team is described in a separate tab in the Summary Report. The seven that are concerned with the defense acquisition process are at Tabs 4 through 8 and Tabs 14 and 15.)
12. DEPSECDEF Memorandum, subject: "Industrial Preparedness Policy Statement," March 6, 1982.
13. USDRE Memorandum, subject: "Improving Industrial Productivity," February 17, 1982, with attached charter for Tri-Service Technology Modernization Draft Policy Committee.
14. Draft DODI 5000.xx, "Productivity Enhancement Program for the Defense Industrial Base," April 21, 1982.
15. Defense Procurement Circular (DPC) 76-3, September 1, 1976 (Executive Summary).

During the *Profit '76* study it became clear that, although profit was a critical factor in decisions to compete for a contract, many other factors influence contractors in their capital investment decisions. The DOD Investment Policy Study Group (IPSG) was formed in early 1976 to identify the other important factors and to find ways to encourage investments by defense contractors that would lead to improved productivity and lower costs.[16]

The Investment Policy Study Group sponsored a number of studies.[17] One, entitled *Investment Policy for Cost Reduction,* is particularly relevant to the issues addressed by Action 5. The study presented its findings in two parts: the general motivating factors for any industrial investment; and the motivating factors that industry indicated would stimulate defense business investment. The general motivating forces include expected net return, availability of funding, cost of money, amount of the capital investment, operating costs, price inelasticity, production capacity, technology, government rules and requirements, competition, and demand.[18]

The Acting Assistant Secretary of Defense (Installations and Logistics) provided a good summary of the Investment Policy Study Group findings concerning major determinants of captial investments in defense business.

> IPSG found that necessity (that is, to produce the product or stay in the business), competition, rates of return, cash flow, and perceived risk were the major determinants to investment in defense business. Of these, *risk in relation to return* and *cash flow* seemed to be the major factors with respect to the analysis of individual investment projects. [Emphasis added.][19]

The motivating factors that industry indicated would stimulate more interest in defense business have been used since 1976 in the development of procurement policy, and were considered in the development of the Acquisition Improvement Program actions.[20]

The Investment Policy Study Group asked The Conference Board, an independent nonprofit institution widely recognized for its research in the fields of business economics and management, to help assess the sources of funds available for capital investment in defense industry. The Conference Board studied the attitudes of decision-makers in the financial world toward prime contractors and subcontractors for the Department of Defense.

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16. Dale R. Babione, "Contractor Investment in Defense Industry—Where Is It?" *Defense Management Journal,* April 1977, p. 9. Mr. Babione was the Acting ASD(I&L).
17. Selected ISPG-sponsored Background Studies: (a) *Profit '76,* December 1976, LMI Report 76-3 (DTIC AD A038 334); (b) *Investment Policy for Cost Reduction,* December 1976, LMI Report 76-9 (DTIC AD A038 335); (c) *The Defense Industrial Base: Executive Summary,* August 1977, LMI Report 76-2 (DTIC AD A044 786 and AD A044 799).
18. *Investment Policy for Cost Reduction,* pp. 1-5 through 1-7.
19. Babione, p. 11.
20. *Investment Policy for Cost Reduction,* p. 1-7.

The Conference Board reported that, in general, the financial community was pessimistic about the defense industry. Reasons given were unfavorable defense contract profits compared to commercial product profits, considering the risks that defense contractors face; uncertainty, both in fulfillment of contracts and winning of future contracts; and a number of other negatives such as the untoward effects on a defense contractor of certain DOD policies, procurement regulations and tactics, and administrative practices. The report stated that "unless these problems can be reduced, if not eliminated, the defense industry is likely to find it increasingly difficult to secure both the short-term and long-term financing it requires."[21]

The Investment Policy Study Group concluded that defense-oriented business would have to depend largely on internal sources of capital for much of its private (non-government) financing of capital investment.[22]

This limited sample of essential background indicates the critical importance of program managers and contracting officers understanding what has motivated contractors. Then they can select the most appropriate means to encourage prime contractors, subcontractors, and suppliers to make productivity-enhancing investments.

Organizing the 16 Interdependent Actions

This collection of 16 actions forms a comprehensive, highly interdependent set of productivity-enhancing initiatives. Each action in the set contributes to the resolution of an important aspect of the overall problem. The sequential listings of the 16 actions used in the Acquisition Improvement Program and Industrial Responsiveness Improvement Program documents referenced earlier do not portray the dynamic system interdependencies that must exist among the actions during implementation.

Thus, to facilitate discussion and promote understanding needed for effective implementation, the 16 initiatives have been organized into the four major interdependent areas of action listed below. Achieving the overall objective of significantly increasing contractor productivity and industrial responsiveness depends on successful implementation of the actions in all four of these major areas. The listing also indicates in parentheses the source of each action, whether one of the subactions, a through h, of Action 5 of the Acquisition Improvement Program, one of the seven recommended in tabs of the TFIRE team's report, or the new action directed by Dr. DeLauer.

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21. James K. Brown and George S. Stothoff, *The Defense Industry: Some Perspective from the Financial Community*, 1976, Report 693, Division of Management Research, The Conference Board, p. 13.
22. Babione, p. 13.

CAPITAL INVESTMENT FINANCING:

Assuring that funds are available to finance productivity-enhancing investments by defense contractors.

—Depreciation of Equipment (AIP Action 5a)
—Milestone Billings and Expediting Payment (AIP Action 5c)
—Economic Price Adjustment (AIP Action 5e)
—Vinson-Trammel Act Repeal (AIP Action 5h)

MANUFACTURING TECHNOLOGY:

Assuring that advanced manufacturing processes and equipment are available for productivity-enhancing investment.

—Manufacturing Technology Program (AIP Action 5f)
—DODI 4200.15, Manufacturing Technology Program (TFIRE Tab 14)
—Patent Policies (AIP Action 5g)

CONTRACTOR MOTIVATION:

Motivating defense contractors to invest in advanced manufacturing technology for defense contracts.

—Profit Levels (AIP Action 5d)
—Return on Investment (ROI)—Productivity Investments (AIP Action 5b)
—DOD Guide: Improving Productivity in Defense Contracting (TFIRE Tab 15)

ACQUISITION PROCESS CHANGE:

Revising acquisition policy and procedures to assure that contractor productivity, industrial preparedness program (IPP), and industrial base issues are integrated into all phases of the acquisition process.

—DODD 5000.1, Major System Acquisitions (TFIRE Tab 4)
—DODI 5000.2, Major System Acquisition Procedures (TFIRE Tab 5)
—DODD 5000.34, Defense Production Management (TFIRE Tab 6)
—DODD 4105.62, Selection of Contractual Sources for Major Systems (TFIRE Tab 7)
—Defense Acquisition Regulation (DAR) (TFIRE Tab 8)
—DODI 5000.xx, Productivity Enhancement Program for the Defense Industrial Base (USDRE)

Now let's examine each of these major areas of activity in some detail to identify what acquisition managers should consider or actions they can take in each area to encourage capital investments to enhance productivity.

CAPITAL INVESTMENT FINANCING

The fact that four of the eight subactions of AIP Action 5 are concerned with the availability of funds required to finance productivity-enhancing capital investments by defense contractors indicates the critical importance of this area. As noted earlier, internal cash flows are the main source of funds available to defense

contractors for financing investments in new technology and capital equipment. Experience has shown that unless total cash flows from long-term defense contracts cover a substantial portion of the operating costs, few contractors will make capital investments to improve their productivity on defense programs.

Each of the four subactions is concerned with a different aspect of helping to assure the level of cash flows needed by contractors to finance capital investments.

Depreciation of Equipment (AIP Action 5a)

This subaction is concerned with increasing cash flows from accelerated capital equipment depreciation. The objective is to make more funds available for timely replacement of less-efficient existing equipment with more highly productive advanced manufacturing processes and equipment. This requires two implementing legislative initiatives. The first was completed when the DOD-supported Economic Recovery Tax Act of 1981 was passed.[23] The act applies to U.S. business in general; however, the provision dealing with depreciation, or cost recovery, of capital assets is particularly important for defense industries. In essence, the accelerated cost recovery system (ACRS) contained in the act defines four categories of capital assets with cost recovery allowed over periods of 3, 5, 10, and 15 years—much shorter times than previously allowed.

Typical types of assets included in each of these categories are as follows: 3 years—autos, light-duty trucks, R&D equipment, and all personal property with an asset depreciation range (ADR) midpoint life of 4 years or less; 5 years—most other equipment and personal property; 10 years—railroad tank cars and real property with an ADR midpoint life of 12.5 years or less; 15 years—real property with an ADR midpoint life of over 12.5 years. Thus, R&D and production equipment can be depreciated for tax purposes, but not for defense contract pricing, in 5 years or less.

Unfortunately, contractors in defense industry are also bound by cost accounting standard (CAS) 409, "Depreciation of Tangible Capital Assets." This standard requires that depreciation, for defense contract pricing purposes, be based on the historical and economical useful life of the asset—a much longer period than now allowed under the accelerated cost-recovery system. The Cost Accounting Standards Board, an agent of Congress, is defunct, and until its authority is transferred to another agency, the standard cannot be revised. Legislation supported by DOD to transfer the Board's authority to the Office of Management and Budget has been included in the 1982 extension of the Defense Production Act.

23. Economic Recovery Tax Act of 1981, Public Law 97-34, August 13, 1981.

Milestone Billings and Expediting Payment (AIP Action 5c)

Progress payments are a major cash flow in a defense firm. This subaction seeks to help alleviate contractor cash-flow problems through improvements in the DOD progress payments process. Defense Acquisition Regulation (DAR) E-503 establishes customary progress payments to compensate the contractor for allowable cost incurred on long-term contracts and to reduce the contractor's investment in work-in-process inventory.

Until recently, the usual progress payment was 80 percent of total allowable costs for contractors other than small business, and 85 percent for small business. To the extent that the contractors' costs were not compensated by progress payments, the contractors were required to carry the cost of working capital, an important source of funds for investments in production equipment.

Because of time lags in recording cost, submitting periodic billings, and receiving payment, however, the contractors' investments in working capital were substantially more than the nominal 15 or 20 percent after progress payments. Data gathered in a recent aircraft industry survey indicated that at an 80-percent rate, progress payments actually provided only about 60 percent of the working capital investment, and the contractor had to provide the balance of 40 percent.[24]

Furthermore, interest paid by the contractor on its share that is financed by borrowing, or the imputed interest on any working capital that is financed from equity, is not an allowable cost recoverable from the government under the existing regulation (DAR 15-205.17). With current high interest rates of 18 percent or more, the contractor's cost of its share of the working capital results in a substantial decrease in realized profits. The Defense Industrial Base Panel noted that this decrease in profits has a direct impact on industry's cash flow and ability to reinvest in capital equipment and new technology.[25]

The objective of this subaction is to improve this cash-flow situation through three implementing actions related to progress payments.

The first implementing action involved two major changes in DOD progress payment policy and procedures. First, the uniform standard progress payment rates were increased. Second, flexible progress payments were provided for any fixed-price-type contract in excess of $1 million when certified cost and pricing data are submitted by the contractor.[26] These changes were implemented when the DAR was revised on October 30, 1981.

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24. *The Ailing Defense Industrial Base: Unready for Crisis*, pp. 46-47.
25. *Ibid.*
26. Defense Acquisition Circular (DAC) 76-31, Item II, October 30, 1981, announced revision of Appendix E and Sections VII and XXIII of the DAR, including a new DAR E-530, entitled "Flexible Progress Payments." This formally documents a new provision for flexible progress payments and increases in the uniform, standard progress payment rates—information that had been provided to DOD personnel through departmental channels in a memorandum by the Acting Deputy Under Secretary of Defense (Acquisition Management), August 28, 1981.

Both uniform and flexible payments are regarded as customary progress payments, as defined in DAR E-503. The uniform standard rate is currently 90 percent for large business concerns and 95 percent for small business. The flexible rate is within the range of 90 to 100 percent, determined by the contracting officer with the aid of a DOD cash-flow model.

The flexible progress payments procedure represents a new approach to contract financing. It enables contracting officers to establish progress payment rates that are tailored to the cash flow of individual contracts. The procedure considers current economic conditions and recognizes that the use of uniform, standard progress payment rates may result in inequitable variations in contractor cash-flow requirements on individual contracts, depending on delivery schedules, on contractor cash management, and on government paying practices.

The cash-flow model is a computer program that has been developed to provide officers with a means of determining flexible progress payment rates. The program, named CASH, is a cash-flow simulation that calculates the highest whole number progress payment rate (not to exceed 100 percent), which limits the contractor's investment in the contractor work-in-process inventory to a minimum of 5 percent.[27]

It is the contracting officer's responsibility to determine the flexible progress payment rate through application of the CASH model. It is the contractor's responsibility to request the flexible rate and to provide the required *pro forma* cash-flow data. Eligible contractors who do not request the flexible rate will be authorized the uniform standard progress payment rate. In no case will the flexible rate be less than the uniform rate.

The second implementing action concerns the use of milestone billing arrangements to alleviate inordinately high contractor financing that would otherwise result from limiting payment to progress payments. Milestone payments are not considered progress payments, but payments in addition to progress payments.

It is the belief of the DOD Contract Finance Committee that most of the situations which required milestone billings in the past can now be equitably addressed through the use of the flexible progress payment procedures. However, there may still be a few situations which warrant the use of a billing milestone procedure. The DOD Contract Finance Committee is now preparing a DAR case to provide new policy coverage on interim acceptance of goods and services, which when incorporated in the DAR will permit the removal of billing milestone coverage from the finance regulations, DAR Appendix E.

The last implementing action seeks to improve the contractor's cash-flow situation by expediting progress and milestone payments. In this context, Con-

27. The DOD Cash Flow Computer Model Users Guide is distributed by the Defense Technical Information Center (Order No. AD A104 091). Future updates will be the responsibility of the Office of the Deputy Under Secretary of Defense (Acquisition Management) for Cost, Pricing, and Finance.

gress enacted a law that requires the government to pay interest on late payments.[28] New procedures required by the act will be included in DAR revisions.

Economic Price Adjustment (EPA) (AIP Action 5e)

This subaction provides for use of EPA clauses to counter the impact of inflation on contractor costs on long-term, fixed-price contracts, and thus, the impact of inflation on cash flow from these contracts.

Major changes to present EPA coverage in DAR 7-106 are being coordinated by the DAR Council. These changes seek to provide for EPA in negotiated fixed-price-incentive (FPI) contracts as well as in fixed-price (FP) contracts. The changes also seek to provide more definitive EPA clauses for established (market or catalog) prices, actual prices, and for the cost-index method to establish uniformity of EPA application.

In accordance with proposed criteria, it will be appropriate to incorporate an EPA provision into an FP or FPI contract when the contracting officer determines in writing that certain costs are unpredictable, are subject to potentially large economic cost fluctuations, are beyond the prospective contractor's control, and are to be incurred during an extended period of contract performance (normally more than 2 years).

After the new EPA policy and clauses have been promulgated, the program manager and contracting officer will be responsible for ensuring that the appropriate EPA clause is included in all appropriate acquisitions; for recognizing the impact of inflation by contract price adjustments made in accordance with the EPA clauses; and for ensuring the EPA clauses are extended to the subcontractors.

Vinson-Trammell Act Repeal (AIP Action 5h)

Repeal of the Vinson-Trammell Act frees time and funds that would have been allocated for the detailed, costly record-keeping required by this obsolete "excessive" profits act.

The Vinson-Trammell Act was enacted in 1934 to protect the government from possible price-gouging by the then expanding shipbuilding and aircraft construction industries.[29] The act limited the profit on completed prime and subcontracts over $10,000 for construction or manufacture of all or part of any new military aircraft or naval vessel. The act required that detailed records on each contract over $10,000 be kept that would support renegotiations to limit ex-

28. Prompt Payment Act, Public Law 97-177, May 21, 1982.
29. Thomas P. Anderson IV, *DOD Profit Policy: Its Effectiveness—The Contracting Officers View*, Unpublished Master's Thesis, Naval Postgraduate School, December 11, 1980 (DTIC AD A098 305), p. 22.

cessive profits. The act was repealed by the DOD Authorization Act of 1982.[30] This action will be completed by a forthcoming revision of the DAR to eliminate the Vinson-Trammell excess-profit provisions.

MANUFACTURING TECHNOLOGY

Two subactions of AIP Action 5 and one action recommended in the TFIRE report deal with manufacturing technology. Their objective is to assure that advanced manufacturing processes and equipment are available to defense contractors to enable them to significantly improve their productivity and responsiveness as elements of the defense industrial base.

Manufacturing Technology Program (AIP Action 5f)

This subaction increases the emphasis on the manufacturing technology programs. The purpose of the program is "to reduce material acquisition costs and lead times by providing the advanced manufacturing technology necessary to improve industrial base productivity in those situations where the private sector is unable or unwilling to do so."[31]

Each of the three services sponsors its own manufacturing technology program. Let us look at four elements of manufacturing technology: (1) generic manufacturing technology, (2) integrated computer-aided manufacturing, (3) manufacturing technology research and development, and (4) technology modernization.

GENERIC MANUFACTURING TECHNOLOGY

The fundamental objective of a generic manufacturing technology project is to transition to the plant floor a technology which is of generic value to the defense industry. An example is the Cast Aluminum Structures (CAST) project. The objective was to demonstrate the feasibility of fabricating large, high-quality, thin-webbed, cast aluminum structures (such as bulkheads) as cost effective substitutes for structures conventionally made using sheet-and-stringer techniques. A bulkhead for the YC-14 aircraft was selected as the factory floor example. Although the YC-14 was canceled, the manufacturing technology was proved. CAST technology is being used on the Air Launched Cruise Missile program and is expected to save $150 million on a buy of 3,400 missiles.

INTEGRATED COMPUTER-AIDED MANUFACTURING (ICAM)

Although manufacturing operations on the plant floor (machining, for example) and above the plant floor (inventory management, for example) can be made significantly more productive if they are brought under computer control, even greater productivity enhancement can be achieved if all of these operations can be

30. DOD Authorization Act of 1982, Public Law 97-86, December 1, 1981.
31. USDRE Memorandum, subject: "Manufacturing Technology Program," September 2, 1982.

integrated under computer control. For example, both machining and inventory control can be (and often are) computer controlled, but further efficiencies can be achieved if the inventory control system has real time "knowledge" of the performance (set-up time, machining rate, tool wear out and replacement times, etc.) of the five-axis numerical control mill. The objective of the ICAM program is to establish the computer-based technologies that will allow complete computer-controlled integration of the manufacturing process. The culmination of this program will be demonstration of the ICAM sheet metal center for manufacture of sheet metal aircraft parts beginning in mid-1985.

TECHNOLOGY MODERNIZATION (TECHMOD)

The objective of a TECHMOD program is to capitalize on existing manufacturing technology by integrating it into a modern manufacturing facility. The focus is on a particular manufacturing facility, such as Air Force Plant 4, where the F-16 aircraft is made. Typically, a TECHMOD program is a joint government-contractor venture in which the government invests in the enabling manufacturing technologies and the contractor invests in the capital equipment and facility. The F-16 TECHMOD program was the pacesetter. The Air Force invested $25 million while General Dynamics invested roughly $100 million. The net shared savings over the life of the program is expected to be $370 million: The government share ($220 million) is realized in terms of reduced F-16 costs, while the General Dynamics share ($150 million) is realized in terms of return on its investment.

MANUFACTURING RESEARCH AND DEVELOPMENT

About 2% of the FY 82 manufacturing technology budget is being directed toward RDT&E of advanced manufacturing concepts. Attention is currently focused on areas such as smart processing which conceives of machines with in-process sensors and adaptive learning capabilities.

The Department of Defense assigns great importance to the manufacturing technology program. The program for the next 5 years calls for doubling the level of funding for manufacturing technology from the $0.7 billion spent from FY 78–82 to $1.6 billion in FY 83–87. The FY 83 budget request contains $6 million in RDT&E, $8 million in operations and maintenance, and $257 million in the procurement accounts for this effort.[32]

The importance of manufacturing technology to the program manager is evident, not only from the point of view of reducing the total cost of a program but also from the point of view of introducing those technologies that are needed to make a program successful. For an overview of the manufacturing technology program, the reader is encouraged to review the proceedings of the 1981

32. Frank C. Carlucci, Testimony before the House Armed Services Committee on the Department of Defense Authorization for Appropriations for FY 1983, February 9, 1982.

Manufacturing Technology Advisory Group (MTAG) Conference.[33] Details about specific MANTECH projects are available from the service MANTECH offices or the Defense Technical Information Center (DTIC). The service MANTECH offices are:

Army: Office of Manufacturing Technology
U.S. Army Materiel Development and Readiness Command
Attn: DRCMT
5001 Eisenhower Avenue
Alexandria, Va. 22333
202-274-8298 or Autovon 284-8298

Navy: Manufacturing Technology Programs
Naval Material Command (Code 064)
Crystal Plaza No. 5, Room 382
Washington, D.C. 20360
202-692-0121 or Autovon 222-0121

Air Force: Air Force Wright Aeronautical Laboratories
Attn: AFWAL/MLT
Wright-Patterson AFB, Ohio 45433
513-255-3300 or Autovon 785-3300

DODI 4200.15, "Manufacturing Technology Program" (TFIRE Tab 14)

The TFIRE team recommended revision of DODI 4200.15 to provide current DOD policy and uniform DOD guidance for the manufacturing technology program. It is now being revised and the new revision should be available in a few months.

Patent Policies (AIP Action 5g)

This subaction seeks to promote contractor innovation to improve productivity. It requires implementing actions in two intellectual property areas—patents and technical data. The first action is to promote contractor innovation by giving contractors all economic and commercial incentives of the patent system. The DAR Subcommittee on Patents reviewed present DOD patent policy and concluded that the current policy permits contractors and subcontractors to acquire title to inventions made under most DOD R&D procurements, and that this fulfills the objective in this area. Accordingly, the Subcommittee prepared an informational item for publication in the Defense Acquisition Circular (DAC) to remind contracting officials of the policies and procedures that

33. "Proceedings of the Thirteenth Annual DOD Manufacturing Technology Conference, MTAG 81," San Diego, Calif., November 30–December 3, 1981, Government Printing Office 1982 507 722 206.

govern patents. The informational item was published in DAC 76-33, dated February 15, 1982.

Some of the key aspects of patent policy that program managers should consider in their efforts to encourage productivity-enhancing capital investments are as follows: assuring that appropriate patent rights clauses are included in contracts; encouraging contractor efforts to make productivity-enhancing inventions; helping contractors acquire patents on these inventions; supporting contractor inclusion of allowable patent-related costs in contracts as an aid in reaching a fair profit objective and achieving cash flows that are necessary to help finance productivity-enhancing capital investments.

The other action is to promote contractor innovation by protecting his proprietary rights and technical data. The DAR Subcommittee on Technical Data and Computer Software Rights reviewed present DOD technical data policy. They concluded that current policy complies with the objective of protecting proprietary rights and data so that contractors will not be afraid to use proprietary data to support their productivity-enhancing capital investments. The Subcommittee prepared a recommended informational item for publication in an early issue of the DAC to remind DOD contracting officials of the policies and procedures that govern technical data rights. The Subcommittee is also working on several DAR cases that will improve protection. The results will be published in future DAR revisions.

CONTRACTOR MOTIVATION

Two AIP Action 5 subactions and one action recommended in the TFIRE report are concerned with motivating companies to become active units of the U.S. defense industrial base, and motivating each company to enhance its productivity through investments in advanced manufacturing processes, equipment, and facilities.

Profit Levels (AIP Action 5d)

This subaction seeks to provide for negotiation of profit levels commensurate with risk and contractor investment, and seeks to ensure that recent profit policy changes are implemented at all levels.

Paragraph 3-808 of the Defense Acquisition Regulation notes that it is DOD policy to use profit to stimulate effective contractor performance. Traditionally profit has been keyed to contractor effort. However, *Profit '76* and related studies indicated that contractor risk, facilities investment, and certain other special factors should also be considered when developing the profit objective for a contract. These additional factors are described in the DAR (paragraph 3-808.4) and constitute the basis of the weighted guidelines (WGL) method of computing the profit objective.

The concern expressed by this subaction is not with the adequacy of the weighted guidelines method, but with the fact that the flexibility granted by the DAR is not being effectively used to stimulate productivity in the defense industrial sector. Indeed, in his June 19, 1981, memorandum, the Deputy Under Secretary of Defense (Acquisition Policy) commented that DOD believes "that the current Weighted Profit Guidelines provide adequate guidance for arriving at reasonable negotiated profits if the proper type of contract has been selected for the individual procurement," and requested that the services forward to the field appropriate instructions concerning the use of weighted profit guidelines and the selection of appropriate contract types.[34]

Paragraph 3-808.6 of the Defense Acquisition Regulation deals specifically with the contract cost risk factor in the weighted profit guidelines. As noted in this paragraph, it is the policy of the DOD "that contractors bear an equitable share of contract cost risk, and to compensate them for the assumption of that risk."[35] The Deputy Secretary of Defense addressed the same issue from a slightly different point of view in his January 6, 1982, memorandum on AIP Action 8:

> There is a need not only to assess the specific risks associated within individual acquisitions, but also to apportion those risks between industry and government in a rational and fair manner.
>
> We must always attempt to limit cost exposure not through the unreasonable transfer of risk to industry, which characteristically ends up costing the government more, but through the selection of appropriate contract forms that provide effective continuing incentives to the contractor to hold costs down.[36]

It is apparent that the selection of contract type and the selection of profit objective constitute a tightly coupled set of actions by which the program manager and contracting officer can deal with contract cost risk.

To achieve the objectives of Action 5, negotiation of profit levels commensurate with cost risk must extend beyond prime contracts down through the whole subcontract structure. Representative James Blanchard, writing in the March-April 1982 issue of *Government Executive*, stresses the need to concentrate on subcontractors and suppliers, some 50,000 companies, in our efforts to inject new vitality into the defense industrial base. He writes that: "several 'disincentives' to industry, especially at the subcontractor and supplier levels, have resulted in many companies deciding they simply cannot afford to compete for Defense business." He concludes a discussion of some of the contributing fac-

34. DUSDRE(AM) Memorandum, subject: "Recommendation 5d of Deputy Secretary Carlucci's 30 April Memorandum, 'Improving the Acquisition Process,' " dated June 19, 1981.
35. DAR, Paragraph 3-808.6(a)(1).
36. DEPSECDEF Memorandum, subject: "Acquisition Study Initiative No. 8—Appropriate Contract Type—Action Memorandum," January 6, 1982.

tors by noting that "In short, the risk is too great."[37]

Program managers and contracting officers have a key role in assuring that cost risk considerations are extended to subcontractors. Subcontractors must not only be able to "afford to compete for Defense business," they must be motivated to compete eagerly and to improve their productivity through capital investments if any substantial improvements in industrial responsiveness are to be achieved.

Investment in facilities also represents a risk to the contractor, particularly if the facilities are uniquely designed for defense business. Here again, it is DOD policy that the contractor not be forced to accept undue risks. Accordingly, the weighted profit guidelines contain provisions designed to compensate the contractor for accepting this risk. (See paragraph 3-808.7.)

A third area to which special DAR provisions apply is productivity enhancements. The incentive to increase productivity and reduce cost within one contract works against a contractor on follow-on production contracts because the reduced level of cost becomes a part of the basis for pricing subsequent defense contracts. The special "productivity reward," provided by paragraph 3-808.8(a), was added to mitigate the loss of profit that occurs when the cost, and thus the price of a follow-on defense production contract, is reduced owing to productivity gains made through prior investments in improved equipment and facilities. (In commercial production, a manufacturer retains all of the savings realized from productivity improvements that lower subsequent production costs.) The addition of the special "productivity reward," DAR 3-808.8(a), also allows a contractor to provide evidence of productivity improvements that reduce the costs on follow-on orders. The contractor can submit this documentation to support inclusion of a special productivity reward in the prenegotiation profit objective of a pending follow-on defense production contract. Contracting officers should become familiar with this rarely used tool for motivating productivity-enhancing investments.

In conclusion, assuring achievement of the objectives of this subaction on each acquisition program and providing feedback for improving the weighted guidelines structure and process are important responsibilities of the program manager and contracting officer. This is where the "rubber meets the road" for using DOD profit policy to provide for negotiation of profit levels commensurate with both risk and contractor investment, and thus to make progress in building a more productive and responsive defense industrial base.

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37. Representative James T. Blanchard, "The Industrial Base: Government Must Take the Calculated Risk," *Government Executive*, March-April 1982, pp. 49–50. Representative Blanchard is Chairman, Subcommittee on Economic Stabilization Committee on Banking, Finance, and Urban Affairs, House of Representatives.

Return on Investment—Productivity Investments (AIP Action 5b)

This subaction seeks to motivate productivity-enhancing investments by structuring contracts to permit companies to share in cost reductions resulting from productivity investments; by modifying the Defense Acquisition Regulation (DAR) profit formula; and by allowing for award fees inversely proportional to maintainability costs. The objective is to motivate each defense contractor to invest in advanced manufacturing technology that will enhance productivity.

This action and the preceding one are interrelated but are quite different in focus. One focuses only on profit levels, while the other focuses directly on motivating productivity investments through fuller use of all tools available under the current DAR, and by modifying the DAR profit formula, if necessary, to effectively motivate productivity investments.

In December 1981, the Acquisition Improvement Task Force identified five barriers to implementation of the latter action.[38] These can be summarized as (1) reluctance of contracting officers to tailor existing clauses to achieve the objectives of this subaction; and (2) lack of understanding of the factors that actually motivate investments on productivity.

Two different implementing actions are indicated to overcome these barriers. The first involves providing better guidance to program managers and contracting officers, within the authority of present DAR policies. The Task Force to Improve Industrial Responsiveness has made substantial progress by developing a draft *DOD Guide: Improving Productivity in Defense Contracting*, located in the TFIRE report.[39]

The second action to overcome the barriers involves the potential modification of the DAR profit formula and related policies. Its objective is to improve existing (or provide additional) incentives for a defense contractor to make capital investments that enhance productivity. In this context, the DAR Pricing Subcommittee has explored potential improvements in contract financing and profit policy. In a report to the DAR Council, the Subcommittee recommended no DAR changes at this time, but suggested that the DAR Council commission a comprehensive study (with industry input) to determine what additional contractual incentives would be required to motivate defense contractors to make productivity-enhancing investments.

DOD Guide—Improving Productivity in Defense Contracting (TFIRE Tab 15)

This guide provides under one cover descriptions of available incentives for encouraging a contractor to invest in improving productivity and reducing production costs.

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38. *Final Report: DOD Acquisition Improvement Task Force*, p. 5b-1.
39. *Summary Report: DOD Task Force to Improve Industrial Responsiveness* (Tab 15).

The Task Force for Improving Industrial Responsiveness developed this guide in response to recommendations in the Report of the Defense Industrial Base Panel of the House Armed Services Committee and the Defense Science Board 1980 Summer Study. Both recommended that the DOD provide incentives to defense contractors to improve productivity by investments in technology, capital facilities, and equipment. As noted above, the guide is also responsive to the part of Action 5 that involves providing better guidance to program managers and contracting officers, within the authority of present DAR policies.

The purpose of the guide is to help program managers and contracting officers to more effectively use all contractual incentives currently available to motivate contractors and subcontractors to invest to increase their productivity on the acquisition program. A "how to" guide, it provides a methodology for establishing capital investment incentives as well as a number of examples of contract clauses that may be tailored to suit the particular situation for any program. While not mandatory, the DOD guide fills a void where very little guidance currently exists to help a program manager improve his contractor's productivity and reduce production costs.

A draft of the guide is being coordinated within the services. Initial distribution is planned in early July. Copies of the guide will also be available to subscribers through the Defense Technical Information Center. The guide will be updated to include new incentives developed under Action 5 and published in future revisions of the DAR.

ACQUISITION PROCESS CHANGE

The Deputy Secretary of Defense in his industrial preparedness policy statement on March 6, 1982, said, "We must weave industrial base considerations into the acquisition process. . . ." He was "going public" on a process that has been working since AIP Action 5 was directed on April 30, 1981. Two teams, described earlier, were established to expedite the weaving—the DOD Task Force to Improve Industrial Responsiveness (TFIRE) on May 20, 1981, and the Tri-Service Technology Modernization Draft Policy Committee on February 17, 1982. The recommendations of the TFIRE team in March 1982 and of the Tri-Service Committee on April 21, 1982, document a program of rapid change in acquisition policy and procedures. The changes will make contractor productivity enhancement and industrial preparedness an integral part of the acquisition process.

Two of the TFIRE-recommended actions apply to other major areas of the integrated program—Manufacturing Technology and Contractor Motivation—and have already been discussed. The other five TFIRE actions and the Tri-Service Committee action form a set of proposed changes in DOD acquisition policy that have the potential for substantially changing the acquisition process. These changes would greatly increase the role of the program manager in integrating industrial preparedness into the acquisition process.

The TFIRE goals of increasing the program manager's involvement in industrial base issues related to his program are as follows:

> a. To insure use of efficient production rates consistent with resources.
>
> b. To insure early identification of potential production problems, as well as opportunities for increasing productivity.
>
> c. To provide a closer link between peacetime acquisition production planning and industrial preparedness planning.[40]

To accomplish these goals, the TFIRE report proposed specific revisions to the following DOD acquisition policy documents (TFIRE Tabs 4 through 8):

—DODD 5000.1, 'Major System Acquisitions"
—DODI 5000.2, "Major System Acquisition Procedures"
—DODD 5000.34, "Defense Production Management"
—DODD 4105.62, "Selection of Contractual Sources for Major Systems"
—Defense Acquisition Regulation (DAR)

Specific changes proposed in the TFIRE report are as follows:

> a. To establish DSARC-reportable goals and thresholds (production lead time, acceleration rate, production rate, and surge production rate) in order to increase program manager management focus on industrial resource contraints and productivity issues early in the acquisition cycle.
>
> b. To provide linkage between peacetime acquisition and surge/mobilization production by requiring that Industrial Preparedness Planning (IPP) be carefully considered when making production rate decisions. The need for IPP funding must be clearly defined and reported to the DSARC principals, along with projections of the impact of not providing such funding.
>
> c. To require use of the most efficient production rates, consistent with resources available. The effect of variations in production rate must be clearly defined and presented to the DSARC principals.
>
> d. To develop a requirement for an Industrial Resource Analysis to allow the program manager to identify the up-front resource requirement (including capital investments) and timing of financial commitments required to have resources available to support initial production.
>
> e. To add surge option clauses and improved definition of Industrial Preparedness Planning concepts to the Defense Acquisition Regulation.
>
> f. To place added emphasis on industrial base issues in advance procurement planning and source selection.[41]

40. *Summary Report*, p. 4.
41. *Summary Report*, pp. 4–5.

The Tri-Service Technology Modernization Committee made its proposed new unified DOD policy on "technology modernization" in the form of a draft DODI 5000.xx, "Productivity Enhancement Program for the Defense Industrial Base." It proposes a DOD policy defining the contracting strategy and the use of financial resources in efforts to increase the rate of defense contractor investment in productivity-enhancing capital equipment.

These joint OSD-service teams, primarily concerned about industrial base issues, have been operating in parallel with those responsible for implementing the directed subactions of AIP Action 5. The weaving of industrial base considerations into the acquisition process started early, owing to overlaps in team membership and professional interactions, and is progressing steadily.

The revised DODD 5000.1, dated March 29, 1982, establishes the basis for incorporating industrial base considerations into the acquisition process by including the TFIRE-recommended acquisition policy changes. These changes require planning to achieve economical rates of production, maintain surge capacity, and conduct realistic mobilization planning; and also require consideration of industrial base issues at DSARC Milestones I and II.

Progress is continuing on the revision and service coordination of DODI 5000.2 and other policy documents identified above. Some may even be published before this article. So the message to program managers is to be aware that the acquisition process is in the process of change, and that there may be a significant change in your responsibilities. It is clear that contractor productivity, industrial preparedness program (IPP), and industrial base issues are key issues in all phases of your acquisition program.

EFFECTIVE INTEGRATION AND IMPLEMENTATION

The findings of the congressional Defense Industrial Base Panel, the working group that recommended Acquisition Improvement Program Action 5 to enhance contractor productivity, and the Task Force to Improve Industrial Responsiveness all indicate a common, grave concern. They are in general agreement that current DOD acquisition procedures have not motivated the rate of capital investments by defense contractors that are required to maintain a sound industrial base, and to improve its productivity to the level needed to assure our national security.

Meanwhile, the new industrial preparedness policy, issued in March 1982 to weave industrial base considerations into the acquisition process, has made a substantial change in the scope of the problem and in strategies available for solving it. It has explicitly expanded the goal to include enhancing contractor productivity on each acquisition program as well as improving the productivity and responsiveness of the defense industrial base as a whole.

Nevertheless, the results of the many studies conducted since 1975 and the lessons learned from past attempts to motivate defense contractors can provide

useful insights for future actions. They help to identify constraints, impediments, and interdependencies that should be faced as realities in the development of strategies for achieving the expanded goal.

Strategic Realities

Analysis of background information, past progress, and the scope of the 16 actions, all from the viewpoint of the new policy, suggests the following as strategic realities in defining approaches for achieving the new overall goal.

1. A significant increase in the productivity of the defense industrial base for surge and mobilization production can be achieved, with a few exceptions, only by aggregating peacetime productivity increases. One exception is the government's need to build special capability for producing some material which is not available from industry sources.
2. Peacetime productivity increases must be achieved mainly through capital investments by contractors on individual defense acquisition programs.
3. "There are no free lunches" for the government, only more or less economical approaches, to increase the productivity of the defense industry through capital investments by individual contractors.
4. Past failures can be attributed largely to acting on individual aspects of the productivity-enhancement problem as though they were unrelated, rather than as though they were interdependent elements requiring coordinated action. Therefore, a systems approach, treating all aspects of the complex problem as interdependent elements, is required to succeed to enhancing the productivity and responsiveness of the U.S. defense industrial base.
5. The rate at which productivity and responsiveness improvements will be realized depends ultimately on the emphasis placed on them by all levels in the defense systems acquisition process, from program managers to the Congress.
6. Each program manager has a major responsibility for "encouraging" and supporting productivity-enhancing capital investments by the contractors on his program, and thus helping improve the productivity and responsiveness of the defense industrial base.

Two Levels of Integration

There is a strong consensus in the Congress, the OSD, and the services that the present adverse trend in defense industry capital investments must be reversed. The strategic realities listed above should help define a practical systems approach for using the four interdependent major areas of activity described earlier as a comprehensive framework for addressing the whole problem.

Reversing the trend, however, will require integration and progress on two levels, at the overall productivity-enhancement "system" level, and at the individual acquisition program level.

At the system level, OSD and the services need to provide continued overall policy direction and management coordination to assure that progress continues to be made in each of the four interdependent areas of activity discussed earlier. Sufficient cash flows to finance the investments must be assured. Advanced manufacturing processes and equipment that will enhance productivity must be made available for investment. Companies must be motivated to compete for defense contracts, and then motivated further to invest in modern technology to enhance their productivity on defense programs. Finally, acquisition policy and procedures must be changed to integrate contractor productivity and industrial responsiveness considerations into all phases of the acquisition process.

These four functions are not isolated or sequential. They comprise a comprehensive collection of 16 highly interdependent actions. These actions must be integrated and implemented as a complete system if the overall objective is to be achieved. Even after the initial implementing actions for all of the 16 actions have been completed, and the rest of the DAR paragraphs and official directives have been revised and distributed to acquisition managers, continued feedback within the "system" will be required to achieve the overall goal. This feedback is needed to help determine the adequacy of the policies, to identify adjustments that may be required, and to communicate operational lessons learned to all acquisition managers in the "system."

But integration at the overall system level is not enough. Each program manager has a major responsibility for "encouraging" and supporting productivity-enhancing capital investments by all of the contractors on his program, both prime and subcontractors.

To fulfill this responsibility effectively, the program manager and contracting officer must become familiar with and then implement the policies and use the aids that are provided by the subactions of AIP Action 5—DAR aids for improving contractor cash flows, modern technology for improving productivity, and incentives for contractors to make productivity-enhancing capital investments.

A key responsibility of every program manager is to identify, for each contractor on his program, those things that will be the contractor's main investment determinants. As indicated earlier in the *Essential Background* section, many different factors motivate companies to make capital investments—expected net return, availability of funding, cost of money, amount of the investment, technology, and competition, to name a few. The primary determinants will be different for different companies and in different contracting situations. At any point, one investment determinant can be more important than all of the others combined. Only after the program manager has identified each contractor's main investment determinants can he select the appropriate combination of policies, aids, technologies, and incentives, and employ the combination to "encourage" each contractor to make a productivity-enhancing capital investment.

Additional productivity-enhancement responsibilities will be defined within the next few months. They will result from the Industrial Responsiveness Improvement Program actions recommended in March and April 1982 to support the new DOD policy on industrial preparedness issued by Mr. Carlucci on March 6, 1982, to make industrial preparedness an integral part of acquisition. When these recommendations are implemented, program managers will have to begin consideration of productivity and other industrial preparedness issues during the conceptual phase of a system acquisition and continue throughout the life of the acquisition.

The stakes are high. A substantial increase in productivity is vital if we are to produce the numbers of defense systems needed to counter the threat to our national security, while also reducing acquisition costs to a level where the nation can afford the numbers needed. ‖

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March 29, 1982
NUMBER 5000.1

USDRE

Department of Defense Directive

SUBJECT: Major System Acquisitions

References: (a) DoD Directive 5000.1, "Major System Acquisitions," March 19, 1980 (hereby canceled)
(b) Office of Management and Budget (OMB) Circular A-109, "Major System Acquisitions," April 5, 1976
(c) DoD Directive 2010.6, "Standardization and Interoperability of Weapon Systems and Equipment within the North Atlantic Treaty Organization," March 5, 1980
(d) through (h), see enclosure 1

A. REISSUANCE AND PURPOSE

This Directive reissues reference (a) to update the DoD statement of acquisition policy for major systems or major modifications to existing systems, and to implement the concepts and provisions of reference (b).

B. APPLICABILITY

The provisions of this Directive apply to the Office of the Secretary of Defense (OSD), the Military Departments, the Organization of the Joint Chiefs of Staff (OJCS), and the Defense Agencies. As used in this Directive, the term "DoD Components" refers to the Military Departments and the Defense Agencies, and the term "Military Service" refers to the Army, Navy, Air Force, and Marine Corps.

C. POLICY

1. General

a. It is the policy of the Department of Defense to ensure that DoD acquisition of major defense systems is carried out efficiently and effectively to achieve the operational objectives of the U.S. Armed Forces in their support of national policies and objectives, and that it meets the guidelines of reference (b).

b. Management responsibility for system acquisition programs shall be decentralized except for the decisions specifically retained by the Secretary of Defense.

c. The management principles and objectives in this Directive shall also be applied to the acquisition of defense systems not designated as major.

2. Acquisition Management Principles and Objectives

a. Effective design and price competition for defense systems shall be obtained to the maximum extent practicable to ensure that defense systems are cost-effective and are responsive to mission needs.

b. Improved readiness and sustainability are primary objectives of the acquisition process. Resources to achieve readiness will receive the same emphasis as those required to achieve schedule or performance objectives. As a management precept, operational suitability of deployed weapon systems is an objective of equal importance with operational effectiveness.

c. Reasonable stability in acquisition programs is necessary to carry out effective, efficient, and timely acquisitions. To achieve stability, DoD Components shall:

(1) Conduct effective long range planning.

(2) Consider evolutionary alternatives instead of solutions at the frontier of technology; for example, preplanned product improvements (P^3I) to reduce risk.

(3) Estimate and budget realistically, and fund adequately, procurement (research, development, and production), logistics, and manpower for major systems.

(4) Plan to achieve economical rates of production, maintain surge capacity, and conduct realistic mobilization planning.

(5) Develop an acquisition strategy at the inception of each major acquisition that sets forth the objectives, resources, management assumptions, extent of competition, proposed contract types, and program structure (such as, development phases, decision milestones, test and evaluation (T&E) periods, planned concurrency, production releases) and tailors the prescribed steps in the major system acquisition decision-making process to this strategy. When the acquisition strategy is approved by the DoD Component, changes shall be made only after assessment and consideration of the objectives of this Directive, and of the impact of such changes on the program.

d. To promote efficiency in the acquisition process, authority will be delegated to the lowest levels of the Component at which a comprehensive view of the program rests. Responsibility and accountability must be clearly established. In particular, the Military Service program manager shall be given authority and resources commensurate with the responsibility to execute the program efficiently. Reviews, such as those by the Defense Systems Acquisition Review Council (DSARC), are a means to evaluate the information required for a decision which higher level authority has specifically reserved and not delegated to the program manager. Reviews will not be used to request data other than those required as a basis for higher authority decisions.

e. A cost-effective balance must be achieved among acquisition costs, ownership costs of major systems, and system effectiveness in terms of the mission to be performed.

f. Cooperation with U. S. allies in the acquisition of defense systems will be maximized to achieve the highest practicable degree of standardization and interoperability of equipment, and to avoid duplication of effort. Mobilization requirements will be a factor considered in evaluating opportunities for international cooperation. (See DoD Directive 2010.6, reference (c)).

g. A strong industrial base is essential for a strong defense. To protect the public interest and foster competition, an ethical distance in business relationships between defense and industry must be maintained, without such buyer-seller relationship becoming adversarial. Technical collaboration with industry must be maintained to achieve major system acquisition objectives and meet technological challenges. The impact of DoD acquisition on the industrial base must also be considered both for the near term and long range implications.

3. Order of Precedence.

This Directive and DoD Instruction 5000.2 (reference (d)) are first and second in order of precedence for major system acquisitions except when statutory requirements override. All DoD issuances shall be reviewed for conformity with this Directive and reference (d) and, if in conflict, shall be changed or canceled, as appropriate. Conflicts remaining after 90 days from issuance of this Directive shall be brought to the attention of the originating office and the DAE for action.

D. DEFINITIONS

1. Operational Effectiveness. The overall degree of mission accomplishment of a system used by representative personnel in the context of the organization, doctrine, tactics, threat (including countermeasures and nuclear threats) and environment in the planned operational employment of the system.

2. Operational Suitability. The degree to which a system can be placed satisfactorily in field use, with consideration being given to availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistic supportability, and training requirements.

E. PROCEDURES

1. Analysis of Mission Areas. As a key to a focus on planning, DoD Components, OSD, and OJCS shall conduct continuing analyses of their assigned mission areas to identify deficiencies or to determine more effective means of performing assigned tasks. From these mission analyses, a deficiency or opportunity may be identified that could lead to initiation of a major system acquisition program.

2. Alternatives to New System Development. A system acquisition may result from an identified deficiency in an existing capability, a decision to establish new capabilities in response to a technologically feasible opportunity, a significant opportunity to reduce the DoD cost of ownership, or in response to a change in national defense policy. Development of a new system may be undertaken only after assessment of alternative system concepts including:

a. Change in U. S. or North Atlantic Treaty Organization (NATO) tactical or strategic doctrine.

b. Use of existing military or commercial system.

c. Modification or improvement of existing system.

3. Phases of the Acquisition Process. There are distinct phases in the acquisition of a new system. Normally, these are concept exploration, demonstration and validation, full-scale development, and production and deployment. These phases are to be tailored to fit each program to minimize acquisition time and cost, consistent with the need and the degree of technical risk involved. For major system acquisitions, the Secretary of Defense will make the decisions described in subsection E.4., below. The Secretary of Defense decision milestones will be tailored to match the selected acquisition strategy. In keeping with the principle of controlled decentralization, the mission need determination has been incorporated into the planning, programing, and budgeting system (PPBS) and the production decision has been delegated to the DoD Component, provided that established thresholds are met. DoD Components shall adhere to this principle by delegating authority to the lowest organizational level feasible. Milestone decision points shall be identified in the acquisition strategy for each major system acquisition.

4. Secretary of Defense Decisions. The Secretary of Defense will make the following decisions in the acquisition of major systems:

a. Mission Need Determination. The mission need determination is accomplished in the PPBS process based on a Component's justification of Major System New Starts (JMSNS) which is to be submitted with the Program Objectives Memorandum (POM) in which funds for the budget year of the POM are requested. The Secretary of Defense will provide appropriate program guidance in the Program Decision Memorandum (PDM). This action provides official sanction for a new program start and authorizes the Military Service, when funds are available, to initiate the next acquisition phase.

b. Milestone I. This first Secretary of Defense major milestone decision is concept selection and entry into the the demonstration and validation phase. This decision is based on a System Concept Paper (SCP) prepared by the DoD Component. The Milestone I decision is a validation of the requirement, based upon preliminary evaluation of concepts, costs, schedule, readiness objectives, and affordability. It provides authority to proceed with the demonstration and validation phase and to develop the system sufficiently to support a Milestone II decision. A review of the acquisition strategy may be substituted for a formal Milestone I review for those programs not requiring a discrete demonstration and validation phase. The Milestone I decision shall

establish thresholds and objectives to be met and reviewed at the next milestone, the acquisition strategy for the recommended concepts (including the nature and timing of the next Secretary of Defense decision point), and a dollar threshold that cannot be exceeded to carry the program through the next milestone.

c. Milestone II

(1) The second Secretary of Defense major decision is program go-ahead and approval to proceed with full-scale development. The production decision at Milestone III is delegated to the DoD Components, provided the thresholds established at Milestone II are met. The production decision may be redelegated to the lowest level in the organization at which a comprehensive view of the program rests. The timing of the Milestone II decision is flexible and depends upon the tailored acquisition strategy approved by DoD Components and the Secretary of Defense at Milestone I.

(a) In a traditional approach, Milestone II would occur at the point where a program moves from demonstration and validation into full-scale development. In some cases, however, it may be desirable to delay this decision until some additional development effort has been accomplished to provide a better definition of performance, cost, schedule, producibility, industrial base responsiveness, supportability, and testing to reduce risk and uncertainty before the commitment to a major increase in the application of resources toward full-scale development is made.

(b) In the case of a delayed Milestone II decision, any full-scale development contracts entered into before Milestone II will be written so that the program can be terminated at Milestone II at least cost to the government.

(2) Whatever timing for Milestone II is selected in the acquisition strategy, both DoD Component and OSD reviews shall be held reasonably close so that program managers will not be required to pass the same milestone more than once. It is generally desirable to maintain design competition up to the Milestone II decision point, or beyond, if it is determined to be a cost-effective acquisition strategy.

(3) The Defense Acquisition Executive (DAE) shall advise the Secretary of Defense on all of the major milestone decisions. Normally, the DAE will be assisted by the DSARC at Milestones I and II. The DAE may call for program reviews at any time during the entire acquisition process. Program reviews are for the purpose of providing specific information to the DAE on a particular aspect of an acquisition program. Program reviews are more limited in scope than DSARC reviews and do not necessarily serve as a basis for a Secretary of Defense decision recommendation.

5. Directed Decisions by Higher Authority. When a line official above the program manager exercises decision authority on program matters, the decision shall be documented as official program direction to the program manager, and a copy shall be available to the DAE. The line official shall be held accountable for the decision.

6. Designation of Major Systems. The Secretary of Defense shall designate those systems that are to be managed as major systems. Normally, this shall be done when the new start is authorized in the PDM. The decision to designate any system as major may, after consultation with the DoD Component concerned, be based upon:

a. Development risk, urgency of need, or other items of interest to the Secretary of Defense.

b. Joint acquisition of a system by the Department of Defense and representatives of another nation, or by two or more DoD Components.

c. The estimated requirement for the system's research, development, T&E, procurement (production); and operation and support resources. A JMSNS is required for all acquisitions for which the DoD Component estimates costs to exceed $200 million (FY80 dollars) in RDT&E funds or $1 billion (FY80 dollars) in procurement (production) funds, or both.

d. Significant congressional interest.

7. Affordability. (DSARC/PPBS Interface). Affordability, which is a function of cost, priority, and availability of fiscal and manpower resources, shall be considered at every milestone and during the PPBS process. The order of magnitude of resources the DoD Component is willing to commit, and the relative priority of the program to satisfy the need identified in the JMSNS will be reconciled with overall capabilities, priorities, and resources in the PPBS. System planning shall be based on adequate funding of program cost. A program normally shall not proceed into concept exploration or demonstration and validation unless sufficient resources are or can be programed for those phases. Approval to proceed into full-scale development or into production shall be dependent on DoD Component demonstration that resources are available or can be programed to complete development, to produce efficiently, and to operate and support the deployed system effectively. Funding availability shall be reaffirmed by the DoD Component before proceeding into production and deployment. To avoid creating program instability, funding changes shall not be introduced without assessment and consideration of the impact of these changes on the overall acquisition strategy for the major system to be acquired. Specific facets of affordability to be reviewed at milestone decision points are set forth in DoD Instruction 5000.2 (reference (d)).

8. Acquisition Time. Minimizing the time it takes to acquire materiel and facilities to satisfy military needs shall be a primary goal in the development of an acquisition strategy. Particular emphasis shall be placed on minimizing the time from a commitment to acquire an operationally suitable, supportable, and effective system to deployment with the operating forces in sufficient quantities for full operational capability. Commensurate with risk, such approaches as developing separate alternatives in high-risk areas; early funding to design-in reliability and support characteristics, lead time reductions through concurrency; experimental prototyping of critical components; combining phases; preplanned product improvement; additional test articles; or omitting phases, should be encouraged. When combining or omitting phases is appropriate, concurrence shall be requested from the Secretary of Defense. Administrative delays associated with briefings and reviews at various organizational levels shall be minimized.

9. Tailoring and Flexibility. The acquisition strategy developed for each major system acquisition shall consider the unique circumstances of individual programs. Programs shall be executed with innovation and common sense. To this end, the flexibility inherent in this Directive shall be used to tailor an acquisition strategy to accommodate the unique aspects of a particular program as long as the strategy remains consistent with the basic logic for system acquisition problem-solving and the principles in this Directive for business and management considerations. The acquisition strategy shall normally contemplate narrowing the number of competing alternatives to eliminate concepts no longer considered viable as the acquisiton process proceeds. This narrowing of competing alternatives shall be accomplished without interrupting the remaining contracts, and need not be timed to coincide with milestone decisions. However, competition for each phase, including, when appropriate, plans for design competition in the early phases and price competition in production, shall be described in the acquisition strategy.

10. Test and Evaluation. Throughout the acquisition process, emphasis shall be placed upon verifying actual performance through T&E. The procedures of DoD Directive 5000.3 (reference (e)) will be integral to all systems acquisition planning and decision-making.

11. Readiness. Readiness goals and related design requirements and activities shall be established early in the acquisition process, and shall receive emphasis comparable to that applied to cost, schedule, and performance objectives. Logistic supportability shall be considered early in the formulation of the acquisition strategy and in its implementation. Projected or actual achievement of readiness objectives will be assessed at each milestone. (See DoD Directive 5000.39, reference (f)).

12. Documentation for Milestone Decisions

a. Mission Need Determination - Justification for Major System New Start (JMSNS). Each major system acquisition program requires a JMSNS to be reviewed by the OSD in the POM review before the new start is included in the DoD budget submission. DoD Components shall prepare JMSNS to document major deficiencies (or opportunities for improvements) in their ability to meet mission requirements when it is planned that such deficiencies be corrected by the acquisition of a major new system or a major modification to an existing system. Joint JMSNS shall be prepared to document major deficiencies in two or more DoD Components. OSD and the OJCS may also prepare JMSNS in response to mission area deficiencies. Joint OSD and OJCS JMSNS shall recommend a lead DoD Component to the Secretary of Defense. The JMSNS is described in DoD Instruction 5000.2 (reference (d)).

b. Milestone I - System Concept Paper (SCP). The SCP provides basic documentation for use by DSARC members in arriving at a recommendation to the Secretary of Defense. The SCP is described in reference (d). The SCP will identify program alternatives based upon initial studies and analyses of design concepts; alternative acquisition strategies; expected operational capabilities; industrial base capacity; readiness, support, and personnel requirements; and cost estimates. The Test and Evaluation Master Plan (TEMP), as described in DoD Directive 5000.3 (reference (e)), will outline the T&E program.

c. Milestone II (and Milestone III, if the Secretary of Defense's decision is required). Decision Coordinating Paper/Integrated Program Summary (DCP/IPS). The DCP/IPS summarizes the DoD Component's acquisition planning for the system's life-cycle and provides a management overview of the program. The DCP/IPS is described in DoD Instruction 5000.2 (reference (d)). The TEMP Directive 5000.3, reference (e)) will define the T&E program for the full-scale development phase.

d. OSD Staff Information Requirements. DoD Components' appropriate staff elements will work with the OSD staff so that OSD can maintain current visiblity over matters such as cost, supportability, T&E, industrial base responsiveness, and production readiness throughout the acquisition process.

e. Secretary of Defense Decision. Secretary of Defense approval of the JMSNS is accomplished in the PPBS when the major system new start is approved by the Secretary of Defense in the PDM. Changes, if any, from the DoD Component approach directed by the Secretary shall be documented in the PDM. For a joint program JMSNS and all program milestones, a Secretary of Defense Decision Memorandum (SDDM) documents each Secretary of Defense decision establishes program goals and thresholds, reaffirms established needs and program objectives, authorizes exceptions to acquisition policy and provides the direction and guidance to OSD, OJCS, and the DoD Components for the next phase of the acquisition.

F. RESPONSIBILITIES

1. The Under Secretary of Defense for Research and Engineering (USDRE) shall be responsible for policy and review of all research, engineering development, technology, T&E, procurement, and production of systems covered by this Directive, and shall:

a. Ensure integration of the acquisition process and the PPBS.

b. Monitor, in conjunction with the Under Secretary for Policy and the Director, Program Analysis and Evaluation (PA&E), DoD Component procedures for analysis of mission areas.

c. Coordinate review of JMSNS provided by DoD Components in the POM to determine whether major system new starts should be included in the PDM.

d. Coordinate with the Assistant Secretaries of Defense (Comptroller), (Manpower, Reserve Affairs, and Logistics), and the Director, PA&E, the interfa of the acquisition process with the PPBS.

e. Be designated Defense Acquisition Executive (DAE). As DAE, the USDRE shall:

(1) Be the principal advisor and staff assistant to the Secretary of Defense for the acquisition of defense systems and equipment.

(2) Serve as a permanent member and the chairman of the DSARC.

(3) In coordination with the other permanent members of the DSARC, the DAE shall:

(a) Integrate and unify the management process, policies, and procedures for defense system acquisition.

(b) Monitor and ensure DoD Component compliance with the policies and practices in OMB Circular A-109 (reference (b)), this Directive, DoD Instruction 5000.2 (reference (d)), and DoD Directive 5000.3 (reference (e)).

(c) Ensure that the requirements and viewpoints of the functional areas are given consideration during staff and DSARC deliberations, and are integrated in the recommendations submitted to the Secretary of Defense.

(d) Ensure consistency in applying the policies regarding NATO rationalization, standardization, and interoperability (RSI) for major systems.

(4) Be delegated authority specificially to:

(a) Designate action officers who shall be responsible for the processing of the milestone documentation and who shall monitor the status of major systems in all phases of the acquisition process.

(b) Recommend the lead Component for multi-Service acquisition programs and provide guidance as to when in the development cycle transition to single Military Service management will occur.

(c) Issue instructions and one-time directive-type memoranda consistent with DoD Directive 5025.1 (reference (g)).

(d) Obtain such reports and information, consistent with the provisions of DoD Directive 5000.19 (reference (h)), as may be necessary in the performance of assigned functions.

(e) Conduct program reviews, as appropriate.

2. The Under Secretary of Defense for Policy (USDP) as a permanent member of the DSARC, shall:

a. Determine whether system requirements as defined in the JMSNS are consistent with policy and planning provisions of the Defense Guidance;

b. Advise the DAE on the international implications, including co-production of any new systems development;

c. Monitor, in conjunction with the USDRE and Director, PA&E, DoD Component procedures for analysis of mission areas.

3. The Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics) (ASD(MRA&L)) as a permanent member of the DSARC, shall:

a. Be responsible for policy on logistics, facility construction, energy, environment, safety, and manpower planning for new systems throughout their life cycle.

b. Ensure that logistics planning is consistent with system hardware parameters, logistic policies, and readiness objectives.

c. Monitor DoD Component procedures for planning and providing post production support to meet system readiness objectives.

d. Coordinate with the USDRE, the Assistant Secretary of Defense (Comptroller), and the Director, PA&E, the interface of the acquisition process with the PPBS.

4. The Assistant Secretary of Defense (Comptroller) (ASD(C)), as a permanent member of the DSARC, shall coordinate, together with the USDRE, the ASD(MRA&L), and the Director, PA&E, the interface of the acquisition process with the PPBS.

5. The Director, Program Analysis and Evaluation (DPA&E), as a permanent member of the DSARC, shall:

a. Monitor, in conjunction with the USDRE and the USDP, DoD Component procedures for analysis of mission areas.

b. Evaluate cost-effectiveness studies prepared in support of milestone decisions for major system acquisitions.

c. Coordinate with the USDRE, ASD(C), and ASD(MRA&L), the interface of the acquisition process with the PPBS.

6. The Chairman, Joint Chiefs of Staff (CJCS), or a designee, shall be a permanent member of the DSARC.

7. Each Secretary of the Military Departments, or designee, shall be a permanent member of the DSARC for major acquisitions involving his Department.

8. The Head of each DoD Component shall manage each major system acquisition assigned by the Secretary of Defense, establish clear lines of authority, responsibility, and accountability, and shall:

a. Appoint a DoD Component acquisition executive to serve as the principal advisor and staff assistant to the head of the DoD Component.

b. Establish a System Acquisition Review Council (SARC) at the Component level to advise the Component head on designated acquisition programs.

c. Ensure that a program manager is assigned and that a program manager's charter is approved as soon as feasible after mission need is determined and resources are allocated in the budget.

d. Ensure that the program manager's tenure is of sufficient length to provide continuity and management stability.

e. Establish management training and career incentives to attract, retain, motivate, and reward competent program managers.

f. Provide a program manager the necessary assistance to establish a strong program office with clearly established lines of authority and reporting channels between the program manager and the head of the DoD Component. Where functional organizations exist to assist the program manager, the relationship of the functional areas to the program manager shall be established.

g. Limit reporting requirements for the program manager to the least required for effective oversight.

h. Monitor major system acquisitions to assure compliance with OMB Circular A-109 (reference (b)), this Directive, DoD Instruction 5000.2 (reference (d)), and DoD Directive 5000.3 (reference (e)).

i. Manage the program when designated lead Component for multi-Service acquisitions under the policies and procedures used by that Military Service. The program manager, program manager's office, and functional elements of each participating Service shall operate under the policies, procedures, data standards, specifications, criteria, and financial accounting of the lead Component. Exceptions, as a general rule, will be limited to those where prior mutual agreement exists, or those essential to satisfy substantive needs of the participating Services.

j. Designate a single major field agency, separate and distinct from the materiel developing and procuring commands and user representative commands, to be responsible for the conduct of operational T&E. This agency will report the results of its independent operational T&E directly to the Military Service Chiefs and Secretaries of the Military Departments.

9. The Defense Systems Acquisition Review Council (DSARC) shall advise the Secretary of Defense on milestone decisions for major systems and such other acquisition issues as the DAE determines to be necessary.

10. The advisors to the DSARC are listed in DoD Instruction 5000.2 (reference (d)).

11. The Program Manager shall be responsible for acquiring and fielding (in accordance with instructions from line authority) a system that meets the approved mission need and achieves the established cost, schedule, readiness, and affordability objectives.

G. EFFECTIVE DATE AND IMPLEMENTATION

This Directive is effective immediately. Forward one copy of implementing documents to the Under Secretary of Defense for Research and Engineering within 120 days.

Frank C. Carlucci
Deputy Secretary of Defense

REFERENCES, continued

(d) DoD Instruction 5000.2, "Major System Acquisition Procedures,"

(e) DoD Directive 5000.3, "Test and Evaluation," December 26, 1979
(f) DoD Directive 5000.39, "Development of Integrated Logistics Support for Systems and Equipments," January 17, 1980
(g) DoD Directive 5025.1, "Department of Defense Directives System," October 16, 1980
(h) DoD Directive 5000.19, "Policies for the Management and Control of Information Requirements," March 12, 1976